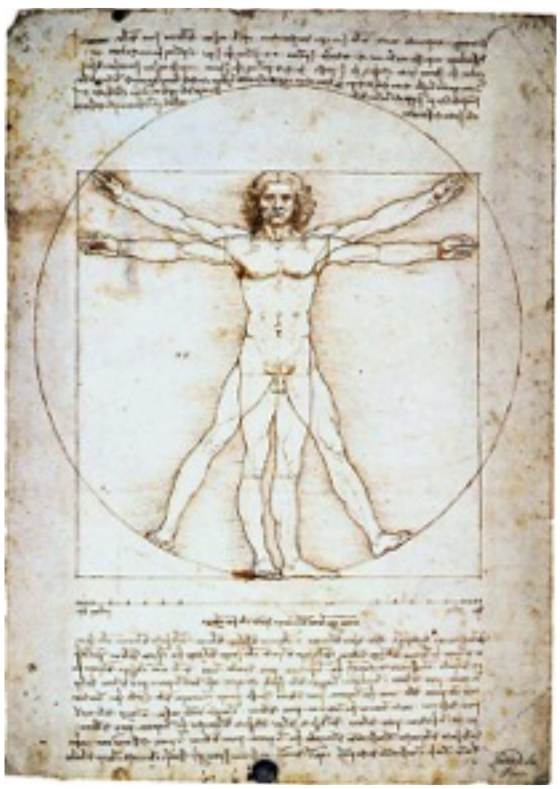
The Physics of Fitness

The Analysis and Application of Bio-mechanical Principles in Resistance Exercise



Douglas Brignole

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The Analysis and Application of Bio-mechanical Principles in Resistance Exercise

by

Douglas Brignole

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Dedicated to the loving memory of my mother,
Ines Ortiz Bolocco de Brignole

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About the Author

Doug Brignole began weight training when he was fourteen years old. His goal was to gain some weight because he was very thin, and his Junior High School coach told him it is better to gain muscle weight than fat weight. So, he convinced his mother to buy him a home barbell set for him, and an adjustable bench. The barbell set came with a “Weight Training Guide Book”.

Doug followed the advice and examples in the book, but immediately realized that many exercises did not feel right. He felt they were either very uncomfortable, or he did not feel the “target” muscle working. This alone is interesting, because most fourteen-year-old kids don’t question the “correctness” of exercises. If they feel any joint strain, or don’t feel the muscle working, they either assume they’re doing it wrong, or that it’s there own individual problem.

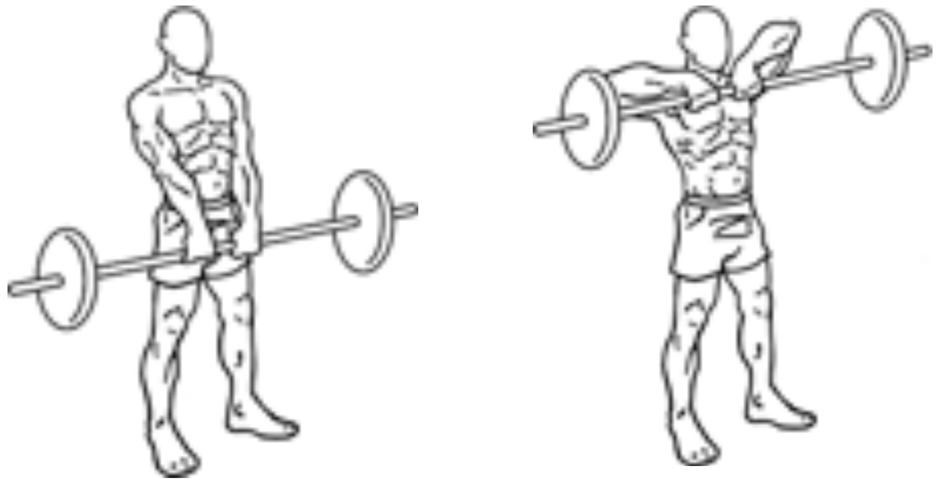
Further, Doug noticed that some exercises DID feel right. They were comfortable. They didn’t seem to twist or distort a joint; they didn’t seem awkward, and they seemed to follow a path that permitted an obvious stretch of the “target muscle”, followed by an obvious contraction of that muscle. Doug thought to himself, “ALL exercises **should** feel like that.”

From the age of 14, Doug felt there should be some similarity in ALL the “good” exercises. They should all follow similar patterns, he thought. “What’s good for one exercise - mechanically speaking - should be good for all exercises, and what’s ‘bad’ for **one** exercise, would be ‘bad’ for **all** exercises.”

For example, “Standing Barbell Curls” felt fine. There was no twisting or discomfort in the wrist, elbow or shoulder. The movement begins and ends in a clear and logical position (starting with elbows straight, and ending with elbows fully bent). The objective is obvious - to first elongate the biceps, and then contract (flex) the biceps.

Conversely, the very first time he did an “Upright Row”, he thought - “this can’t possibly be right”.

For those who don’t know how this exercise is performed - one begins by holding a barbell (with a narrow grip) while standing, arms straight down, with the bar resting against the front of the thighs. Then one pulls the bar straight up, close to the torso, all the way up until the bar is just under the chin (elbows kept higher than the hands). Then one lowers the bar and begins again.



When the bar is held at the level of the thighs, it's comfortable enough on the wrists. But as the bar is being raised, and the elbows flair outward, it becomes impossible to hold the bar with straight wrists. One is forced to bend his (or her) wrists **sideways**, and even then, one can't grip the bar with the kind of firmness one would like. One is left holding onto the bar with his/her fingertips, wrists cocked sideways to an almost painful degree. This was clearly not good, Doug thought. It also seemed unnecessary, given the supposed objective of the exercise - to work the shoulders.

Further, there was no obvious objective in the "*Upright Row*", as there was in the "*Standing Barbell Curl*". Although the starting position was easy to understand ("arms straight down"), the **ending position** was not as clear as that of the "*Standing Barbell Curl*". The *Barbell Curl* ends when the biceps are fully contracted and the elbows are fully bent, but the "*Upright Row*" does not seem to end at a point where the shoulder muscles (Deltoids) contract. One cannot feel the contraction - the sense of completion -

at the top of the *Upright Row*, the way one does at the top of the Barbell Curl. This seemed “wrong” to Doug, or at least “less correct” than one would expect.

Doug also noticed that this same exercise tends to rotate (twist) the upper arms forward at the shoulder (known as “internal rotation of the humerus”). This was uncomfortable and hinted at the possibility of future joint strain. This **also** seemed unnecessary for Deltoid development. In other words, there did not seem to be any logical benefit in exchange for this contortion, discomfort and potential injury risk.

Other exercises which Doug also felt were “wrong” - at least to some degree - included Leg Raises, Parallel Bar Dips and Overhead Presses. So, even at a very young age, Doug was somehow able to feel whether an exercise was “correct”; he was analytical enough to question it, and curious enough to dedicate the rest of his life to understanding what makes an exercise “good” or “not as good”, from a mechanical standpoint.

Doug began competing in bodybuilding at the age of 16. By the time he was 19 years old, he had won Teenage Mr. California and Teenage Mr. America. Of course, every one of his workouts have been “exploratory”. Yes, he did many conventional exercises - always contemplating what it was about each movement that felt “right” or “wrong”, and which characteristics would qualify it as “good” or “not quite good enough”.

Doug won the 1982 AAU Mr. California title at the age of 22, and he won his division in the 1986 AAU Mr. America and Mr. Universe competitions, at the age of 26. From 1991 through 2016, he competed in a number of competitions, ending his competitive career in 2016, at the age of 56 - forty years after he began. At the time of this writing, the outcome of his final competition - the World Championship - is unknown. Although, it’s likely Doug will either place very high, or win, his final competition.

Few competitive bodybuilders have had a 40-year span of competitions. Fewer still have been able to achieve “as good” or “better” condition when they were over the age of 50, than they achieved at the age of 26 - but this is the case with Doug. His condition at 54 and 56 years old, was / is arguably “as good” or “better” than when he won the Mr. America division at the age of 26. This is due entirely to his improved understanding of biomechanics, and the ability to make each workout **much more efficient** than “conventional” workouts. This results in more benefit, with less strain on the joints, and less wasted energy.

Doug’s physique has been regarded as perhaps one of the top 50 “most aesthetic” of all time. Some bodybuilding fans have included him in the top 10, although this is extremely subjective. In any case, Doug’s physique has been lauded for its balance, symmetry, definition and elegance. He is one of a handful of bodybuilders who never competed in “professional” competitions, yet is compared with the likes of Frank Zane, Francis Benfatto and Bob Paris - some of the greatest professional bodybuilders in the history of the sport.

In 1984, Doug opened up a beautiful 10,000 square foot gym, and managed it for eleven years. He has conducted seminars throughout the U.S., as well as overseas. He has written numerous articles for the leading fitness publications - most notably “Iron Man Magazine” - and has provided “continuing education credits” (CECs) to Personal Trainers. He is the co-author of “Million Dollar Muscle” - along with Adrian Tan, PhD professor of sociology - an academic book which explores the fitness industry from a sociological perspective.

However, it is possible that Doug’s greatest contribution has been the rational and scientifically sound insight he has brought to the field of resistance exercise for physique development, in his biomechanics teachings. These insights are profound, and will likely change the way resistance exercise is taught, the way machines are designed, the way gyms are equipped and the way trainers are certified. More importantly, they will allow consumers to achieve their fitness goals with the utmost efficiency and safety.

The author - Doug Brignole - at the age of 16 (far left), 22 (center) and 54 (far right).

Chapter One

Levers of the Human Body

The human body is made up of levers. Limbs and appendages (a collection of bones acting as a unit) are acted upon by muscles at specific articulations, thereby producing movement.

All levers magnify resistance and force. The universal laws of physics, as they apply to levers, work the same in regard to the levers of the human body.

Therefore, all resistance exercises we perform are subject to magnification of force, as well as other mechanical principles. Understanding and working around these principles allows us to work with optimum efficiency, in the pursuit of physique development.

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Anatomical movement is caused by muscles pulling on the various "levers" of our body, thereby moving joints (also known as "articulations"). Sometimes those levers are individual bones, like a femur (thigh bone). Other times they are comprised of two (side by side) bones, like a forearm or a lower leg. Sometimes the "lever" is a group of bones, like a hand or a foot. Still other times, it's the entire torso or the head (the skull) acting as a lever. All of these levers are acted upon by muscles, which cause joints to bend, extend or rotate, thereby creating movement.

The fundamental basis of resistance exercise is the deliberate loading of a lever (a forearm, for example), for the purpose of strengthening and developing the muscle(s) which causes that particular lever to move.

The resistance imposed on any muscle is due to the load being used (barbell, dumbbells, cables, machines, etc.), **which is then magnified** by our "levers" (bones / limbs), **and then further altered** by other factors (i.e., the angle of our levers relative to the direction of resistance, and relative to the angle of our muscles pulling on our levers), which we'll discuss later.

During a *Standing Dumbbell Curl*, a 10 pound weight which is placed in one's hand, will impose a challenge on the Biceps that is MORE than the 10 pounds. The weight in one's hand is **magnified** by a factor that is directly related to the length of one's forearm.

In normal, day-to-day resistance training, it is not necessary to know the exact amount of this magnification. However, it is important to have a sense of the magnification itself, and how a given exercise compares with another exercise, based on the length of the lever being used.

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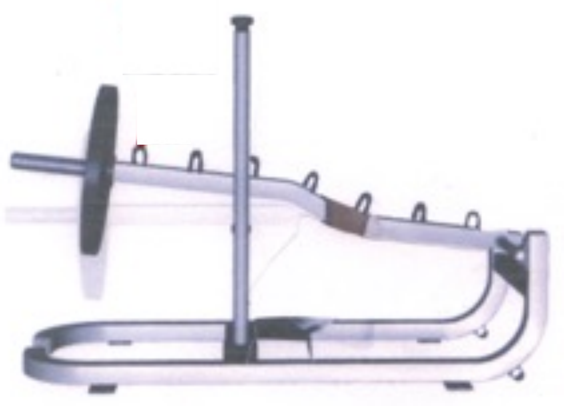
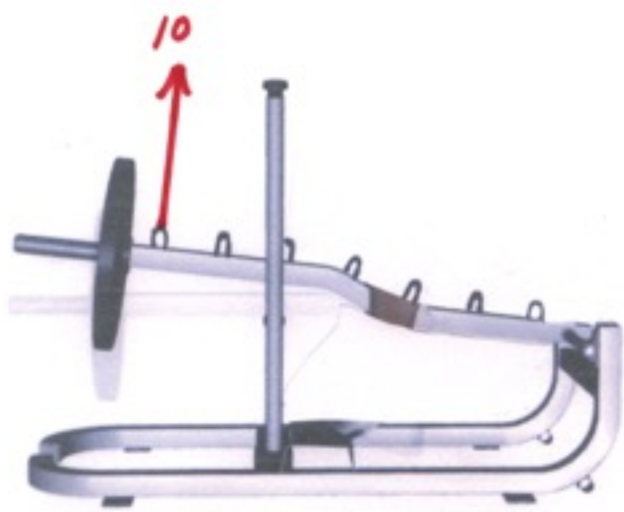
When I do seminars, I typically use a lever device (like the one below) to demonstrate the magnification effect of levers. Using this same lever device, I also demonstrate another concept - "Mechanical Advantage and Disadvantage" - which we'll discuss in Chapter 8.



I begin by asking the audience to imagine that this lever device in front of us, is their forearm, and that the weight-holder on the end of the lever, is their hand. The pivot on the other end of the lever device is their theoretical "elbow".

I take a 10 pound plate and slide it onto the holder. I then ask them this question: "If you held a 10 pound weight in your hand, with your forearm parallel to the ground, how much resistance would your Biceps be holding?" The simple answer may seem to be "10 pounds", and that is the answer that most people call out.

I then pick up a fishing scale, which has a hook on it. I connect that hook to the first loop on the lever - the one that is closest to the weight at the end of the lever. Essentially, this is the place where the "wrist" would be. I pull straight up on the fishing scale, until the lever lifts slightly off it's perch, and ask an audience member to read the measurement on the scale. "10 pounds", the observer calls out. "Fine", I say.

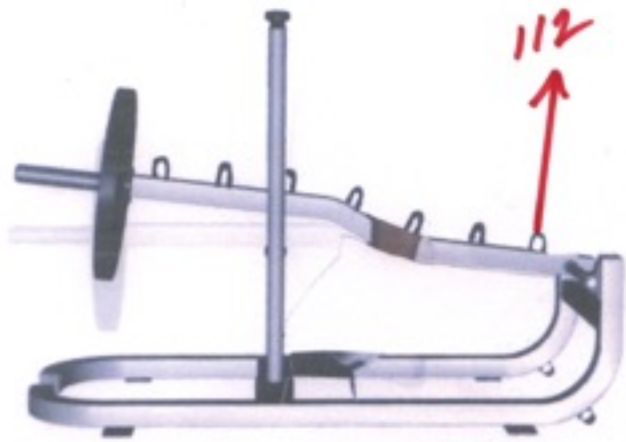


I then move the fishing scale to the next hook, moving away from the "hand", in the direction of the "elbow". I pull up on the scale, and ask the audience member to read the measurement. "23 pounds", the observer calls out.

I move the fishing scale to the following hook, further away from the hand. I pull up on the scale, and ask for the reading. "38 pounds", the audience member calls out.

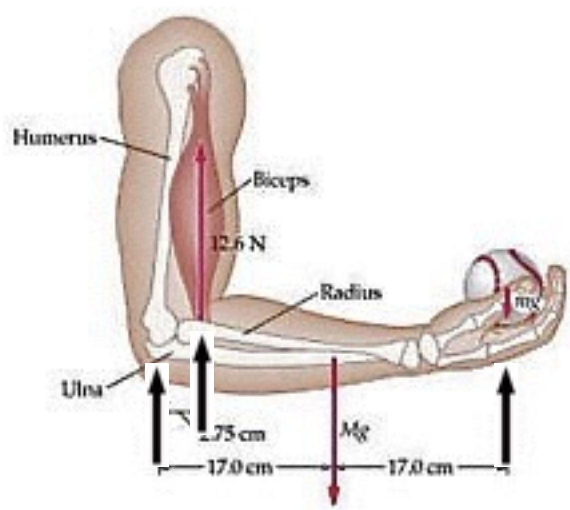
I continue moving the fishing scale down the length of the lever device, and each time I move it, the scale measures a higher amount. Finally, I arrive at the final hook on the lever - this one positioned approximately an inch away from the pivot. This is the actual place (more or less), where one's Biceps would attach to the forearm, and from which the Biceps would be pulling on that forearm.

I pull up on the scale, and ask for the reading. "112 pounds", the assistant calls out. Of course, by now the audience has become restless.



I playfully ask, “Isn’t that still a 10 pound weight you’re holding in your hand?”. “Did some people say their Biceps would be pulling 10 pounds when their hand is holding a 10 pound weight?”, I ask rhetorically.

You see, the Biceps **never** pulls directly on the weight that is in your hand. The Biceps pulls on the lever (your forearm), which is holding the weight that is in your hand. And, it is pulling on the forearm from a point that is about 12 inches behind the weight, and about 1 inch in front of the elbow (the pivot). That is a 12-to-1 ratio. The weight - therefore - is magnified by a factor of 12 (approximately), depending on the length of one’s forearm.



This is illustrates how a lever magnifies resistance. Regardless of the weight that is actually being held, lifted, pushed or pulled - the operating lever (the limb) will **always** magnify the amount of resistance which the muscle must move.

There are additional factors which further alter the resistance (increasing or decreasing it), and we'll learn about them shortly. But it's important to understand that muscles never pull directly on weights. **They pull on levers** which are holding weights, and this happens in accordance with the laws of physics.

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There are three types of levers. They are known as "Class One", "Class Two" and "Class Three". For the moment, let's examine one of these types, and see how it matches one of the levers in the human body. Then, we'll apply the formula which is used to calculate the magnification of any lever.

Let's look at a **Class Three** lever. This type matches that of the **forearm / elbow / Biceps**. In this example below, notice that the lever is horizontal. This means that it is perpendicular to gravity (which is vertical). Keep that in the back of your mind, for now. This is important, as you'll see in subsequent chapters.

In the illustration above, the "Fulcrum / Pivot" would be the **elbow**. The "Load" would be the **weight in hand**. The "Effort" would be the upward force of the **Biceps**.

Of course, the point from which the "Effort" (Biceps) is actually applied, would be closer to the Pivot (i.e., the elbow) than is depicted in the illustration above. But a Class 3 Lever simply means that the "Effort" is **between** the Pivot and the Load.

Below is the **universal formula** which determines the amount of magnification of levers. **The same formula applies to all three types of levers**, even though the three factors change position, depending on which type of lever is being used.

$$R \times RA = F \times FA$$

1. “R” represents “Resistance”. This is the amount of weight that is placed upon the lever. Sometimes it’s called FL (“Force **Load**”) or just “Load”.

2. “RA” represents “Resistance Arm”. This is the lever. More specifically, it is the **Length** of the Lever that is between the “Effort” and the “Load”. In the case of the Class 3 Lever shown above, it is “the Forearm” - as measured NOT from the hand to the elbow, but from the hand to the connection of the Biceps on the forearm - the place where the upward “Effort” is being applied.

3. “FA” represents “Force Arm”. This is the distance between the Pivot (the elbow), and the point at which the “Effort” is applied on the Lever (e.g., the insertion point of the Biceps onto the forearm).

4. “F” represents “Force”, which is to be calculated. This is the amount of muscle force required to hold up the lever, given the other three factors.

To illustrate the math involved in this scenario, let’s use a 15 pound weight, and plug this figure into the **“R”** equation above. 15 pounds is the resistance.

Now, let’s assume that the distance between our “Effort” (the Biceps attachment on the forearm) and the weight-in-the-hand is 12 inches. So, we’ll put a “12” in the **“RA”** (“Resistance Arm”) spot in the above equation.

We’re trying to calculate **“F”** (Force required of the Biceps), so we’ll leave that blank for now.

And finally, let’s assume the distance between the elbow and the Biceps connection on the forearm is one inch. So, we’ll put a “1” in the **“FA”** spot in the above equation.

Here’s what it would look like, at this point:

15 pounds x 12 inches = ______ (Force) x 1 inch

Resistance (R is 15) x **Resistance Arm** (RA is 12 inches) = **Force** (?) x **Force Arm** (FA is 1)

Now, let’s just do the math……

(15 x 12 = 180) = ? x 1

180 divided by 1 = 180

Therefore…….

F = 180 pounds

In other words, **the Biceps needs to generate 180 pounds of force**, in order to hold a 15 pound weight in the hand, assuming an average length forearm.

(Note: This is while holding the forearm in a horizontal position, and a Biceps pulling perpendicularly on the forearm, as would be the case when the elbow is at 90 degrees, and we're standing upright.)

Of course, a forearm that is longer than 12 inches (as measured from the hand to the Biceps insertion near the elbow) would require a little more than 180 pounds of force by the Biceps. A forearm that is less than 12 inches long would require a little less than 180 pounds of force.

In any case, the amount of force the Biceps needs to generate, when "curling" a 15 pound dumbbell, is much more than just 15 pounds. This is reason enough to not concern ourselves with whether we're lifting "heavy enough", provided the target muscle feels challenged.

Using this formula, you could calculate how much force your Biceps would have to generate if you were curling 25 or 30 pounds. In fact, you could calculate the amount of force any muscle would have to generate, provided you know (approximately) the length of the Resistance Arm, the length of the Force Arm, and the weight being used - plus, another couple of factors, which we'll discuss soon.

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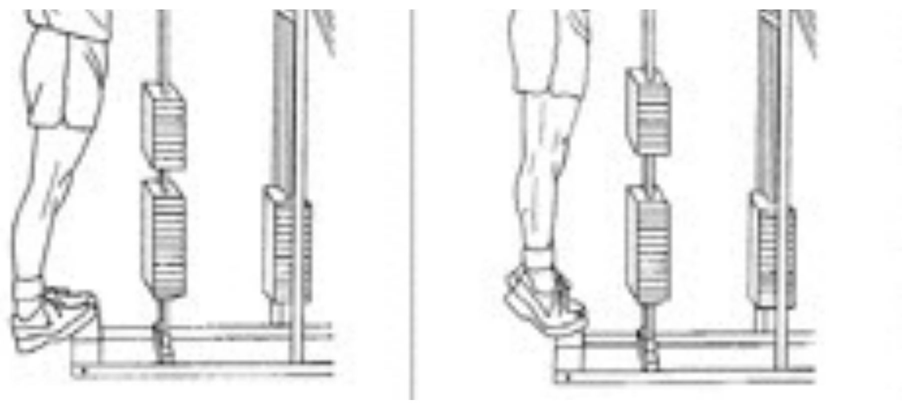
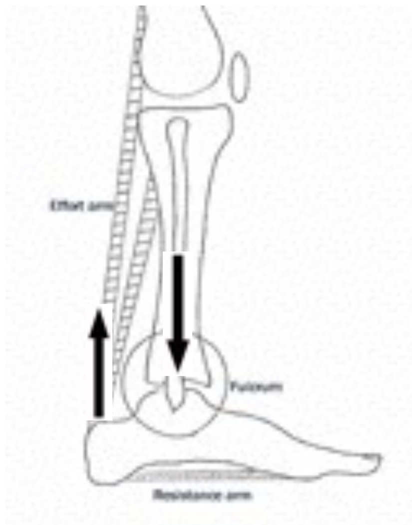
Class 2 Lever

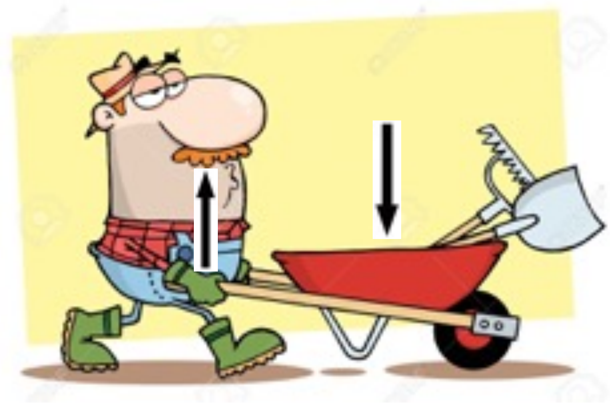
A Class 2 Lever is one that has the "Effort" being applied at the **end** of the lever, rather in between the Load and the Pivot.

It requires that the weight ("Load") be placed in the **middle** of the lever, with the muscle force being applied at the **end** of the lever. An of example of this is when we are doing a "*Standing Calf Raise"* - illustrated below. However, this type of lever is not commonly found on the human body.



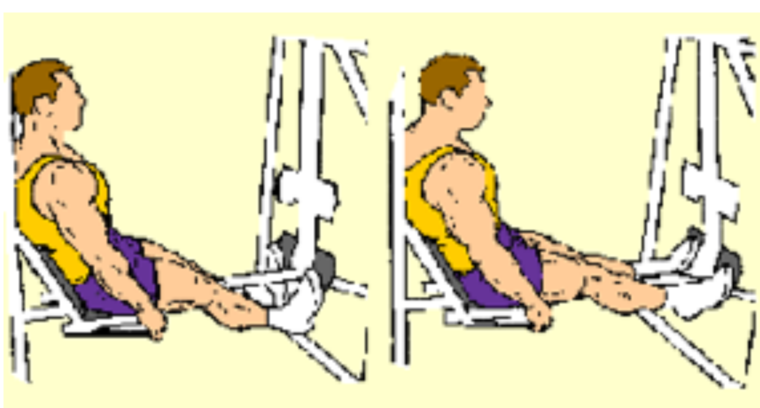
During a *Standing Calf Raise*, a person's bodyweight, plus whatever additional weight is placed on the shoulders, transfers all the way down to the ankle, and bears **down** on the joint of the foot (see below-left). When the Calf muscle contracts, it pulls upward on the heel bone, which elevates the mid-foot carrying the Load. The ball of the foot is the pivot, because that's the part that's stationary.



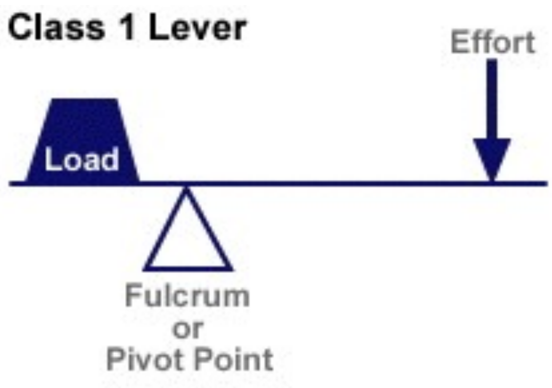


In the illustration above-right, we can see how this is similar to a man using a “Wheelbarrow”. The Force is the man pulling upward on the handles; the Load is whatever is in the red container, bearing downward with its weight. The wheel is the pivot.

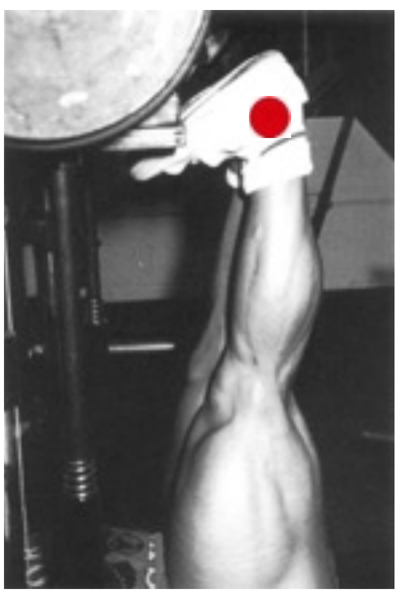
However, watch what happens when we do a “*Seated Leg Press Calf Extension” -* illustrated below. The seat (and therefore the body and **ankle**) are stationery - NOT the ball of the foot. The “Load” is now the weight on the machine - not bodyweight. The pivot is now the ankle, because it’s stationary.

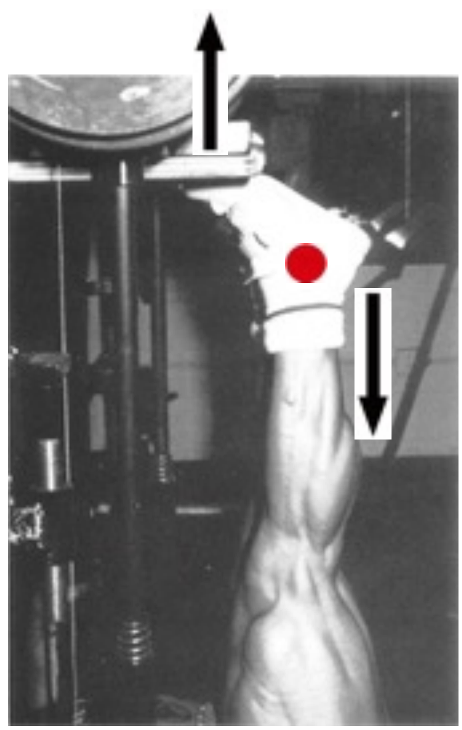


So, despite this still being a Calf exercise, its characteristics are that of a Class 1 Lever - NOT a Class 2 Lever. The definition of a **Class 1 Lever**, is having the pivot **between** the Load and the Force. See the illustration below.



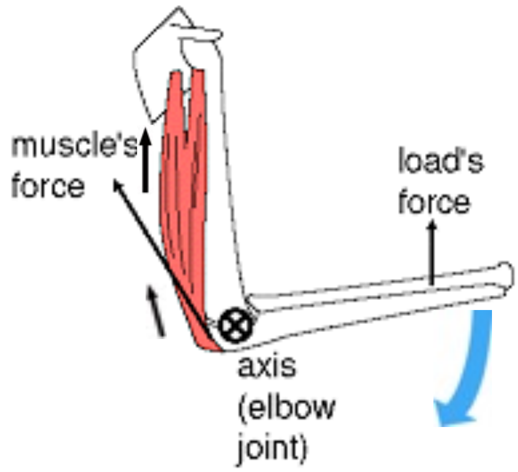
Here's is a better view (below) of how a "Leg Press Calf Extension" functions as a Class 1 Lever. The ankle is the pivot (red dot) because it's stationery; it is pivoting between the Calf and the forefoot. The Load is now bearing down at the end of the lever, instead of in the middle of the lever.





Let's look at another example of a **Class One Lever**.

In the illustration below, we see an illustration of an arm, viewed from the side. The Triceps muscle is highlighted in red. We see the elbow (small circle) and we see the forearm with the "up" arrow, indicating the upward pull of a cable. This represents would happens during a "*Triceps Cable Pushdown"*.



The forearm is the “Resistance Arm”. The elbow is the “Pivot”. The **Triceps** is the “Effort”.

As the Triceps muscle of the arm contracts, it pulls upward on its insertion on the back of the forearm (similar to the heel bone of the foot, during Calf Extensions). This causes the pivot (the elbow) to extend / push the forearm downward, against the upward resistance of the cable. The pivot is between the Force and the Load - a Class 1 Lever.

Whenever we are lifting a weight (moving resistance), we are using one of the three types of levers - either a Class 1, Class 2 or Class 3. In all cases, the formula for calculating the amount of resistance with which a muscle is loaded, is always the same. But quantifying the exact amount of resistance that is loaded onto a muscle is not especially important, certainly not on a day-to-day level.

What does matter is that we understand that our limbs are levers, and whenever we are doing resistance exercise, our bodies are subject to the laws of physics. And one of the principles of physics (as it relates to levers) is that **the weight we are moving, is NOT the resistance our target muscle is getting**.

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Primary Levers & Secondary Levers

In the context of Resistance Exercise, the bone that is directly connected to your target muscle (by way of muscle insertion), is considered the **“primary lever”**. Whatever OTHER bone is directly attached to the primary lever, but not to the target muscle, is considered the “**secondary lever**”.

For example, if your target muscle is your Pectorals, than the humerus (the upper arm bone) would be the **primary lever**, and the forearm would be the **secondary lever** - in this particular case.

When we were discussing the Biceps, we focused our attention exclusively on the forearm, as the “operating lever” of the Biceps. In that case, there really is no “secondary lever”, other than the hand. But it’s very short, relative to the forearm, so it’s mostly inconsequential.

However, in situations like that of the Pectorals (and a few other muscles), it gets a bit more complicated. This is because the end of the humerus does not have a hand attached directly to it (mock illustration below). We cannot hold a weight ONLY with the humerus. The hand (which will hold the weight) is attached to the end of the **forearm**, which is a separate lever. So, we must consider the role of the forearm, even though the Pectoral does not connect directly to the forearm.

Since the forearm bends at the elbow, it is not only an extension of the upper arm. Depending on **which direction** the elbow bends and **how much** it bends, it GREATLY affects the physics of what the upper arm is doing - in terms of the Pectorals (and any other muscle that attaches to the humerus). Therefore, as the “secondary lever” to the humerus, what the forearm does during any Pectoral exercise, matters a great deal.

This is not only true in regard to exercises for the Pectorals. It’s true any time we load a muscle by way of two (or three) separate levers. It applies to exercises for our Latissimus dorsi, our Deltoids (all three parts), our Glutes, and our Hip Flexors.

A secondary lever could affect an exercise in several ways. It could act purely as an "extension" of the primary lever - **adding to its length**, which would result in more magnification of the load. A secondary lever could also "double back" over a primary lever, thereby **reducing the effective length** of the primary lever, and decreasing its magnification of the load. It could also act as "neutral" lever - neither increasing or decreasing the magnification of the primary lever.

In addition, a secondary lever could also ROTATE its primary lever. In other words, if the secondary lever is allowed to bend in a direction that is NOT in line with the primary lever, it would "torque" (turn) its primary lever. If this is intentional - as would be the case when doing a "good" exercise for the Infraspinatus and/or Subscapularis (Rotator Cuff muscles of the shoulder joint) - it's fine. However, if it's unintentional - as would be the case when improper form is used on pressing motions - it could be potentially injurious.

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Let's examine some of these possibilities, so that we can fully understand what a secondary lever is, how it interplays with its primary lever, and how it could effect the muscle(s) that connect to the primary lever.

In the illustration below, we see a person doing a *Supine Dumbbell Press*, for the Pectorals. The humerus is the primary lever, because our target muscle is directly connected to it. The forearm is the secondary lever. In the illustration below, the forearm is behaving as a "**neutral**" secondary lever, because it is mostly **parallel** with gravity. As long as the forearm stays perfectly vertical, it will behave as a neutral secondary lever.

Now, let's look at the example below. Here, the forearm is **not** staying vertical (parallel with gravity) - at least not in this descended position of the movement. When the forearm breaks from a vertical position - entering various degrees of horizontal - it becomes an "active" secondary lever.

Because the forearm is leaning **away** from the where the upper arm begins (at the shoulder), it is essentially “lengthening” the primary lever (the upper arm). This **increases** the magnification effect on the Pectorals.

(Note: The forearm is also the primary lever of the Biceps, so the fact that it’s leaning “out” (laterally) actually does two things. It increases the load to the Pectorals, and it also engages the Biceps. This is not necessarily good - depending on the circumstances. But for now, let us just acknowledge that it’s happening.)

In the example below, the forearm is tilting **inward** (instead of outward) - and this **decreases** the load to the Pectorals. This is because it is effectively “shortening” the upper arm lever, by doubling back over it.

(Note: The forearm is also the primary lever of the Triceps, so the fact that it's leaning "inward" actually does two things. It decreases the load to the Pectorals, and it also engages the Triceps. Again, this is not necessarily good - depending on the circumstances. But for now, let us just acknowledge that it's happening.)

Whenever a secondary lever tilts **away** from the far end of the primary lever, it **increases** the magnification of the primary lever. Whenever a secondary lever tilts **toward** the far end of the primary lever, it **reduces** the magnification of the primary lever.

Calculating exactly how much a secondary lever increases or decreases the magnification of the primary lever (due to tilting outward or inward), can be very complicated. But it's also not necessary.   However, it is good to have a sense of it, in terms of percentage.

The easiest way is to estimate this, is to draw a vertical line straight up through the beginning and the end of the secondary lever, and also of the primary lever - like I've done below. As you can see, the **distance** between the two lines of the forearm is about **half** the distance of the upper arm. This indicates that the secondary lever has added about 50% more "length" to the primary lever - thereby adding about 50% more magnification to it.

The same simplified formula can be used to approximate the **reduction** of magnification, caused by a secondary lever "doubling back" over the primary lever.

In the example above, the distance between the “forearm lines” is about half that of the “upper arm lines”. This indicates that the secondary lever has reduced the effective length of its primary lever by HALF, which means the magnification has also been reduced by about half.

Of course, it’s more sensible to use a slightly lighter weight, and then allow the secondary lever to **increase** the magnification of that weight, to the Pectorals. It’s LESS sensible to use a weight that’s heavier than the Pecs can handle, and then allow the secondary lever to **reduce** the magnification of that weight, to the Pectorals.

Often, the ego will try to convince guys to use the heavier weight (allowing them to believe they are simply stronger), but then reducing the load to the Pecs, by way of the inward tilting forearm. But, that’s actually foolish because the Pecs get them same load either way. It’s just that the heavier weight strains the joints more, and increases the risk of injury.

A muscle does not “know” how much weight is in your hands. It only “senses” how much load it’s required to move. Several factors - not the least of which is the position of the secondary lever - determine the actual resistance that is loaded onto the target muscle. It is **never** the actual amount in your hands.

It’s far more efficient - and wise - to use the least amount of weight possible, with the maximum efficiency. This loads a muscle with the most resistance, and the least amount of wear and tear on the joints.

Tilting the Secondary Lever on a Different Plain

Separate from an "inward" tilt or an "outward" tilt, the forearm could also tilt **backward** or **forward** - when doing Supine Dumbbell Press. This is a potentially dangerous "mistake", in terms of the secondary lever. It would create "external rotation" of the humerus or "internal rotation" of the humerus, respectively - as shown below - and could result in a serious injury if the weight being used in substantial.

When the forearm is NOT vertical (when viewed from the side), it means that the it has entered a different plain - separate from the one on which the Pectorals are working. In either one of these cases, the forearm will begin "falling" either toward the head or toward the feet ("externally" or "internally"), and will require the use of the Rotator Cuff muscles to prevent the forearm from falling into worse alignment.

Since the weight typically used for Pectoral exercises is substantial, this could seriously overload the Rotator Cuff muscles, causing an injury. This will be discussed in greater detail in the Rotator Cuff (anatomy) section, in Chapter 26. But for now, let's just acknowledge that a Secondary Lever, can greatly influence an exercise, and NOT necessarily in a good way.

Evaluating the Effect of a Secondary Lever on the Squat

There are a number of characteristics that determine the amount of "Load" on a muscle. These include the following:

1. The **length of the Operating Lever**, which includes the "addition" or "subtraction" provided by a Secondary Lever (if applicable)

2. The **degree of "perpendicular-ness" of the Operating Lever**, relative to the direction of resistance

3. The angle at which the target muscle is able to pull on its Operating Lever (Mechanical Advantage / Disadvantage)

Any exercise, including the Squat, can be evaluated using the above mentioned characteristics. Number two (above) - will be discussed in detail in chapters 2 and 4. Number three (above) - will be discussed in detail in chapter 3. After reading those chapters, you can come back and look at the illustration below, and you'll have more informed perspective about it.

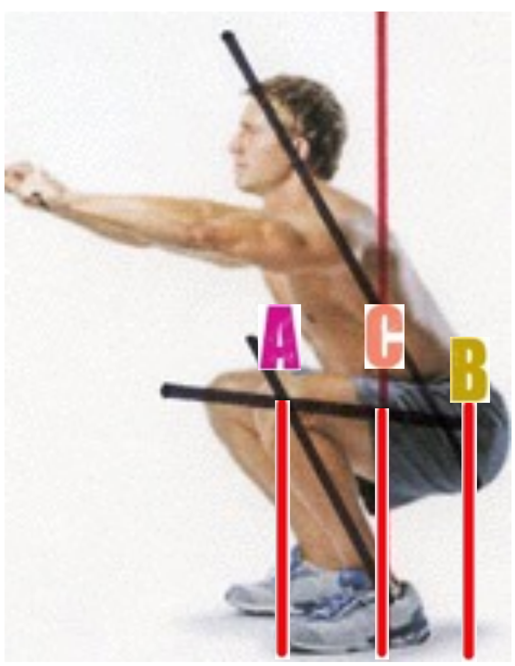
For now, let's focus our attention on Number one (above) - the "**Length** of the Operating Lever", and the effect of the **Secondary Lever**.

In the Squat analysis (below), there are three "levers" in play.

1. The **lower leg** (tibia / fibula - acting as the primary lever of the Quads, and also as the secondary lever to the Glutes)
2. The **upper leg bone** (femur - acting as the primary lever of the Glutes)
3. The **torso** (acting as the primary lever of the Erector spinae and the Glutes)

Because we are discussing "secondary levers" in this chapter - we **primarily** want to evaluate the effect of the Lower Leg on the Squat, as it relates to the Glutes.

The muscle attachment of the Glutes is on the femur (upper leg bone) - so the femur is the Primary Lever of the Glutes. However, during a Squat, the resistance is applied to the Glutes by way of the floor / **LOWER LEG** / femur. It is not being applied directly by the femur. So, the Lower Leg is the Secondary Lever of the Glutes - and it plays a significant role in that task.



Just as we did when evaluating the Supine Dumbbell Press (in terms of the forearm tilting away from the shoulder, or toward the shoulder), we are focusing our attention here on the Lower Leg (as the secondary lever), and the fact that it is “doubling back” over the femur.

The distance from “A” to “B” represents the femur length. The average femur is about 19 inches long. The distance between “A” and “C” is the amount by which the Lower Leg (as the Secondary Lever) is reducing the effective length of the femur. As you can see, it’s reducing it by about half. The distance between “B” and “C” is all that’s left of the femur length (about 10 inches), after the “reduction”.

This also give us a clue as to “why / how” it is that a person is able to Squat so much weight. The combination of a reduced femur length (caused by the “doubling back” of the lower leg) **and** the angle of the Tibia (shown here at about 30 degrees from neutral - meaning the Quad is only getting about 1/3 of the load that is being used), allows more weight to be moved.

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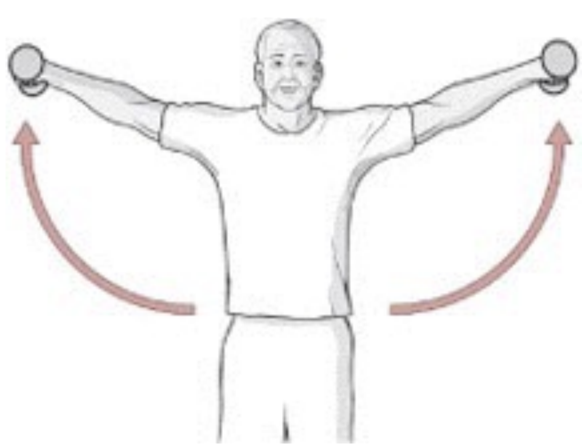
Standing Side Dumbbell Raise

Here again, we are forced to deal with the fact that, in order to load the Deltoids, we must involved the forearm as a secondary lever. Unless we are using a “side raise machine” that presses only against the humerus (upper arm bone), there is no way of holding a dumbbell only with our humerus (the primary lever of the Deltoids). By holding a weight with our hand, we automatically engage the forearm as a secondary lever.



When the exercise is performed with straight arms - like the illustration above - the forearm acts only as an extension of the upper arm. This essentially “lengthens” the primary lever, thereby increasing the magnification of the resistance. That’s fine. Of course, some people prefer using a short lever, because it allows them to use more weight. But a longer lever loads the Deltoids as much, or more, as a shorter lever does, even though a lighter weight is used.

The average adult male arm (with straight elbow) is about 30 inches long, from shoulder to hand. This means that whatever weight you’re using in your hand while doing “Straight Arm Side Raises”, will be magnified by a factor of (at least) 28. A 10 pound dumbbell, therefore, could be magnified to approximately 280 pounds (when the arm is perpendicular with the ground), in terms of how much load the Deltoid has to generate to move it.

However, every once in a while, we see someone in the gym doing this exercise with their elbows bent - shown below.

This is NOT a better version of a Side Raise - mechanically speaking. The appeal might be that it’s perceived at “new” (and therefore, “better”). Or, it might be that one quickly discovers they can use a heavier weight, and “that would be better” (NOT).

Yes, you CAN use more weight this way, but that’s only because a bent arm magnifies the resistance HALF as much as a straight arm. But this is irrelevant, because whether you use a straight arm and half as much weight, or a bent arm with twice as much weight, the Deltoid gets the same load. Either way, it equals the same NET resistance. The Deltoid does not work any harder, by using a heavier weight with a bent arm.

At this point, you might be thinking that if it’s all the same - whether using a bent arm with more weight OR using a straight arm with less weight - “why not do what’s more “gratifying” (i.e., using a heavier weight)?”. However, there’s a very good reason why **not** to make that choice.

When the elbow is straight, the forearm (working as a secondary lever to the humerus) ONLY acts as an **extension** to the humerus. However, **when the elbow is bent**, the forearm enters into another plane of resistance. Instead of "lengthening" the humerus, the **forearm will now act as a "rotator" of the humerus**. It would be like using the forearm as the handle of a crescent wrench, to TURN the humerus in the shoulder socket.

In response to this "loaded forward-rotation", the external rotator muscles of the humerus (i.e., the Infraspinatus and Teres minor) must fight to prevent further forward rotation. This could easily strain the external shoulder rotators because the weight typically used for Deltoids might be too much for these smaller muscles.

This version of the *Standing Side Dumbbell Raise* (with bent arm) would be - at the very least - an **inefficient** way of working the Lateral Deltoids. You'd be spending more effort - because **you're using more weight** than with the straight arm version - but you would **not be loading the Deltoids any more**. It could also be a risky choice, as the rotator cuff muscles could easily be overloaded.

Some people might try to suggest that working the rotator cuff muscles would be good. In general, I would agree. But attempting to do so **while** still giving the larger, stronger Deltoids a challenging workout, would risk injuring the rotator muscles and would likely compromise the Deltoid stimulation. Plus, there is a better exercise for the external rotators of the shoulders - which will be explained in Chapter 26.

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SUMMARY

The concepts of "lever length" and "secondary levers" are the most foundational bio-mechanical issues related to resistance exercise.

The “lever length” issue is involved in every single (resistance training) exercise we do. The issue of “secondary levers” is involved almost any time we try to load a target muscle, by applying the resistance to a lever that is NOT directly connected to the target muscle, by way of muscle attachment.

It’s important to understand how (and why) a **longer** lever magnifies a load **more**, and a **shorter** lever magnifies a load **less.**

Also important is understanding how a **secondary lever** can increase or decrease a load produced by a primary lever, and how a secondary lever can cause strain to muscles unrelated to our target muscle, if the secondary lever moves **out of the alignment** with the primary lever.

Chapter Two

Active Levers and Neutral Levers

A lever that is perfectly parallel with the direction of resistance is "neutral". It does not require any force to hold it in that position. It is balanced, either over its base or under its pivot.

Conversely, a lever that is perfectly perpendicular with the direction of resistance is fully "active". It is at its "heaviest" at that position, in terms of the effort required to hold it there. The effort required to hold a given lever at that position, will be more than it would be in any other position.

Therefore, an exercise for a particular muscle, should allow the muscle's operating lever to encounter a mostly "active" position, somewhere in its range of motion. This would allow the target muscle to be loaded with all or most of the available resistance.

It is <u>inefficient</u> to do an exercise that does NOT provide a target muscle's operating lever with that encounter - instead, only providing it with positions that are mostly "neutral".

A lever that is mostly "neutral" only loads its operating muscle with a fraction of the available resistance. Therefore, one must use much more weight than is necessary, in order to adequately challenge the muscle that operates that lever.

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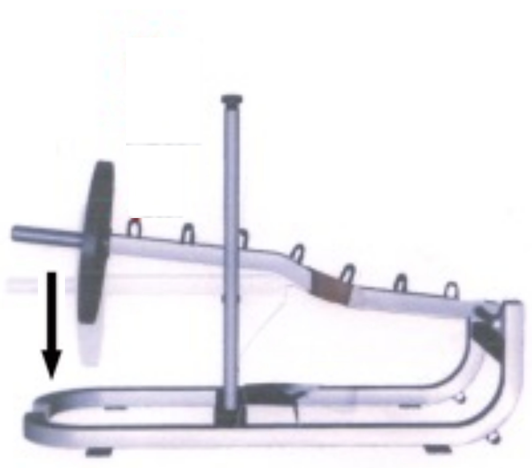
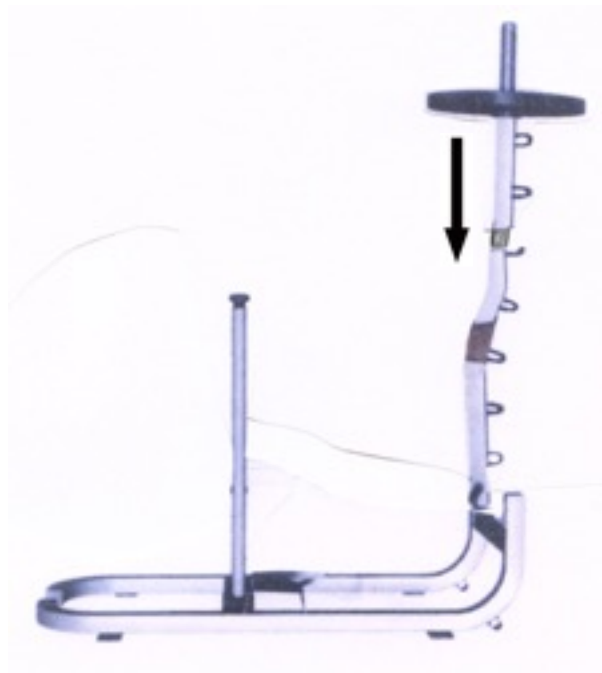
The definition of "efficiency", as per the Merriam-Webster Dictionary, is: ***"effective operation as measured by a comparison of production with cost (energy, time and/or money)"***. In other words, "efficiency" - in the pursuit of muscle growth - means getting the most muscle stimulation, with the least wasted effort and the least amount of injury risk.

In the previous chapter, we learned that the **amount of muscle force** required to move a weight that is placed on a lever, is MORE than the actual weight. The lever “magnifies” the weight that is on the lever, in proportion with the **length** of the lever.

In this chapter, we are learning that the amount of resistance that a weighted lever loads onto a muscle **depends on the p<u>osition</u> of that lever**, relative to the direction of resistance.





In the illustration above-<u>left</u>, the lever is **perpendicular with gravity** - which makes it a fully “**active**” lever. That is when the lever is at its “heaviest.”

In the illustration above-<u>right</u>, that same lever is **parallel with gravity** - which makes it a fully “**neutral**” lever. That is when the lever is at its “lightest.”

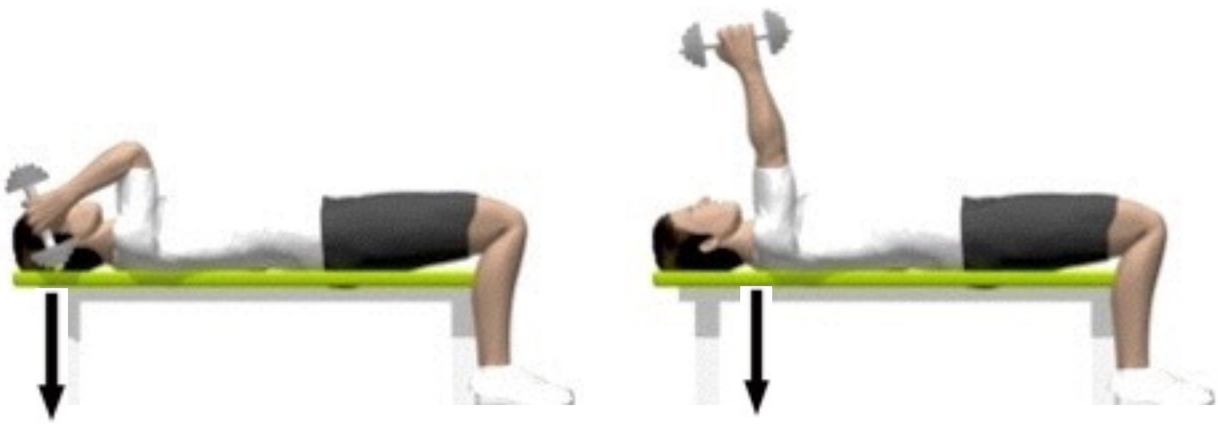
Regardless of how much weight is placed on the lever - it will still be NEUTRAL, when that lever is perfectly parallel with gravity (or whatever the direction of resistance is). It requires NO force to hold the lever in that position. It is balanced directly over (or under) the pivot.

Therefore, the **most efficient** exercises are the ones that allow the operating lever (of a target muscle…the forearm, as the operating lever of the Triceps, for example) to go through a fully or mostly “active” position, somewhere in the range of motion - ideally, in the early part of the range of motion (this will be explained later).

The exercises that are “not so good” **never** allow the operating lever (of the target muscle) to go through a mostly “active” position. The worst exercises only allow the operating lever to be mostly “neutral” through the **entire** range of motion, which is **most** inefficient.

Comparing an Efficient Lever with an Inefficient Lever

Let’s say we want to work our TRICEPS muscle. Below, we see a standard “*Supine Dumbbell Triceps Extension*”. Let’s assume this person is using a 20 pound dumbbell in each hand.



In the above illustration, the forearm (which is the “operating lever” of the Triceps) moves from a position that is just below horizontal (above-left), up to a position that is almost completely vertical (above-right).

Even though we cannot see **gravity**, we know that it always pulls straight down. In reference to a clock, “free weight gravity” always pulls in a 6:00 direction. For clarity, I’ve placed a downward arrow in the photos above, indicating the direction of gravity. This way, you can compare the angle of the forearm, relative to the “direction of resistance”.

(Note: When using a cable, the “direction of resistance” is toward the pulley, even though gravity pulls the weight stack straight down.)

In the exercise above, when the forearm is horizontal, it is PERPENDICULAR with gravity - and that would make it fully “active”, at that point. A lever that is perpendicular with resistance is a **“100% lever”**, which means that 100% of the “available resistance” is loading the muscle that operates that lever. In this case, it’s the Triceps.

As the forearm moves upward, it ultimately reaches the top of the range of motion, ending in a near vertical position. At that point, it is almost **parallel** with the direction of resistance, and therefore mostly **"neutral"**. A fully neutral lever provides ZERO load to the muscle that operates it.

Now, let's do a bit of math to see (approximately) how much resistance each 20 pound dumbbell loads onto each Triceps, in the exercise above. Keep in mind, the following calculation is a simplified formula. The exact formula would be more complicated, and it is not necessary, for our purposes. This simplified method is accurate enough to get a sense of efficiency.

The average length of a (adult male) forearm, plus a bit of the hand, is approximately 12 inches. So, any weight held in the hand would be magnified by a factor of approximately 12 - when the lever is perpendicular with resistance. Therefore, we multiply the 20 pound weight by a factor of 12, which equals 240 pounds, and then we multiply it by 100% (because it's a **fully** perpendicular lever). Multiplying by 100% essentially means that there's no "reduction" of resistance.

So, 240 pounds is approximately how much load is put onto each Triceps, when a person uses a 20 pound dumbbell on this exercise (above), and is at the point in the range of motion when the forearm is most "active" (perpendicular with gravity).

(Note: There is an additional factor which further magnifies resistance - known as "mechanical "disadvantage" - which will be discussed in the next chapter. But, for the sake of simplicity, we'll assume here that the only magnifier is the lever length).

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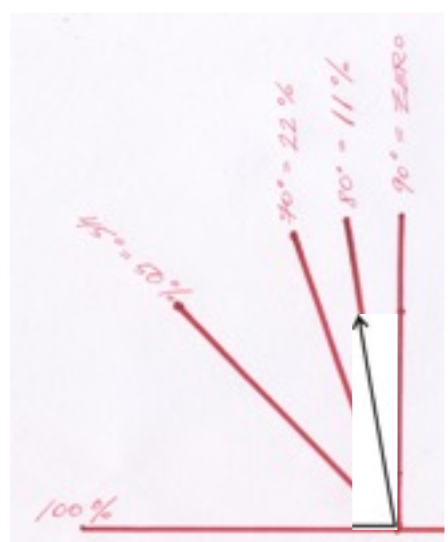
NOW - as a comparison - let's look the exercise below - *Parallel Bar Dips*.



In the photo above-left, we can see that this person's elbow is bent at approximately 90 degrees, which is the same degree of bend that occurs in the descended position of the ***Supine Dumbbell Triceps Extensions***. However, during **this** exercise, the forearm is still mostly **parallel** with gravity, at the same degree of elbow bend. It only tilts from the vertical (neutral) position by approximately 10 degrees - if that.

The illustration above-right, is a graph I made to show that the **vertical** position (known as the 90 degree mark) - is **parallel** with gravity, and is a neutral lever. The next line (to the left) is the 80 degree angle, which is 10 degrees less than vertical. It constitutes **11%** of the distance between fully vertical and fully horizontal. Compare that line, with the angle of the man's forearm.

So, if a horizontal lever is 100% "active", and a 90 degree lever is completely "neutral", than an 80 degree lever is 11% "active".

This means that - during *Parallel Bar Dips* - the percentage of "available resistance" that is loaded onto the Triceps is only about 11%.

Now, let's do the (simplified) math on these figures.

Let's say this man (doing *Parallel Bar Dips*) weighs 180 pounds. He has two arms, so that's 90 pounds per arm. His forearm is the same length as the man doing the *Supine Dumbbell Triceps Extensions,* so that results in a magnification factor of 12. He's using an 11% lever - so we'll add these figures into the equation.

180 pounds (bodyweight) divided by 2 (arms) = 90 x 12 (forearm length magnification) x 11% = 118.8 pounds. Each Triceps is being loaded with about 119 pounds of resistance, in the descended position.

Let's compare the "efficiency" of each exercise. In the first exercise, the man was lifting a total weight of 40 pounds (two 20 pound dumbbells), which loaded each of his Triceps with 240 pounds. In the second exercise, the man was lifting his entire bodyweight of 180 pounds, but only loading each his Triceps with 119 pounds.

Parallel Bar Dips require the man to use 4.5 times MORE resistance (180 lbs.) than when he is doing *Supine Dumbbell Triceps Extension* (40 lbs.) - yet he is loading his Triceps with less than HALF as much load.

It should be **obvious** which the "better" (more efficient) Triceps exercise is, when we examine the physics of each. The reason Parallel Bar Dips rate so poorly as a Triceps exercise, is because the forearm (as the operating lever of the Triceps) is mostly NEUTRAL throughout the entire range of motion. It is only able to deliver a fraction of the available resistance to the Triceps.

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I’m sure some of you are now thinking that *Parallel Bar Dips* FEEL like they’re providing more load than just 119 pounds. And you are correct. 119 pounds is only what is being loaded onto each Triceps. 180 pounds is certainly much heavier than the 40 pounds used in the first exercise, so doing *Dips* would naturally feel much more difficult, than would S*upine Dumbbell Triceps Extensions*. In fact, just holding your bodyweight at the top of the Dipping bars is challenging (with arms straight), even though NO lever is loaded perpendicularly (below-left). There is enormous (vertical) pressure on your arm bones, wrists and hands - even without descending into the movement.

When you begin your descent (above-right), the resistance will **mostly** load the muscles that operate the **<u>humerus</u>** (upper arm bone) - because THAT is the lever that is mostly perpendicular with gravity (not the forearm). Notice the horizontal position of the humerus, in the photo above-right. THAT is the “active” lever in this exercise, but that lever is NOT operated by the Triceps. It’s being operated by two **other** muscles (Anterior Deltoids and Pectorals), in this scenario.

You might now be thinking, “great - those other muscles also need to be developed”. That may be true. However, as we’ll learn in more detail in the Anatomy section of this book, the **pathway** that is traveled by the humerus, during *Parallel Bar Dips*, is **more** that of the **Anterior Deltoids**, than of the Pecs. This means that there is much more load going to the Anterior Deltoids (arguably too much load, for the safety of the Anterior Deltoids), and much less on the Pectorals. The movement of the humerus, during Dips, is NOT the ideal movement for Pectoral function. There are far better Pectoral exercises, and there are also much better (and safer) Anterior Deltoid exercises.

This is one of many comparisons, which demonstrates the difference in **efficiency** between using a mostly perpendicular (**“active”**) lever during an exercise, versus a mostly parallel (**“neutral”**) lever.

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Here’s another example (below) of an exercise that is intended as a Triceps exercise, but proves to be very **inefficient** in that effort, because the forearm (as the operating lever of the Triceps) is mostly in the neutral position throughout the entire range of motion.

Known as “***Bench Dips***”, this exercise causes the operating lever of the Triceps - the forearm - to be mostly parallel with resistance (gravity), rather than mostly perpendicular with it. It causes the upper arm bone / lever (the **humerus**) to be the more active lever. This (again) causes the majority of the load to be placed on the Anterior Deltoid, even though that is not the intended goal of this exercise.

In addition, this exercise over-stretches the Anterior Deltoid **even more** than occurs when doing Parallel Bar Dips. This is fairly obvious, based on the fact that the hands are constantly **behind the torso**. With Parallel Bar Dips, at least they are mostly alongside the torso.

This is a mostly unproductive exercise (for Triceps), which could easily strain the Anterior Deltoid. This can be easily assessed when one understands the difference between an **active lever** and a **neutral lever**.

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Exercise Assessment

As has now been established - when assessing a resistance exercise, one of the most important things to ascertain is which lever is more or less perpendicular with resistance (active or neutral), through the range of motion of that exercise. However, identifying this requires that **two** other factors be known:

1. The **direction of resistance** ("free weight" gravity, cables, or machine)

2. The **muscles** which operate the levers in question

As a prelude to the Anatomy Section, and for the purpose of fully grasping this concept of "**active**" and "**neutral**" levers in exercise assessment, here is a **basic** list of Physique Muscles and their corresponding Operating Levers. This would help with #2 above - knowing which muscles are operating the levers that are moving during an exercise.

Muscle	Operating Lever
Pectorals	Humerus (upper arm bone)
Lats	Humerus (upper arm bone)
Deltoids (lateral, posterior& anterior)	Humerus (upper arm bone)
Trapezius	Scapula / Clavicle (shoulder carriage)
Biceps	Radius / Ulna (forearm)
Triceps	Radius / Ulna (forearm)
Quadriceps	Tibia / Fibula (lower leg)
Hamstrings	Tibia / Fibula (lower leg)
Glutes	Femur (upper leg bone)
Hip Flexors	Femur (upper leg bone)
Calves	Foot
Forearms (flexors / extensors)	Hand
Obliques	Spine / torso / pelvis
Abdominals	Spine / torso / pelvis
Erector Spinae	Spine / torso / pelvis

As a rule, the muscle that activates the "operating lever", is always the one that the operating lever moves toward, **during concentric muscle contraction**. When we do "Curls", the operating lever (forearm) moves **toward** the Biceps. When we do Triceps extensions, the operating lever (forearm) moves **toward** the Triceps. When we do Leg Extensions, the operating lever (lower leg) moves **toward** the Quadriceps.

There are other criteria that factor into the assessment of an exercise, besides whether the target muscle's operating lever is working efficiently. But for now, let's start with assessing whether the primary lever is mostly "active" or mostly "neutral", during a given exercise.

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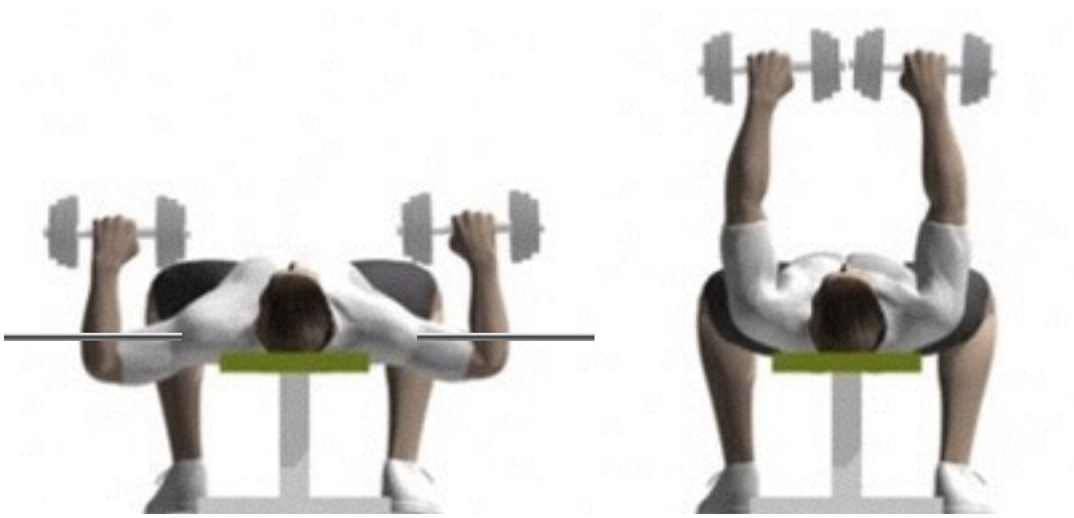
Supine Dumbbell Press

(as a Pectoral exercise)



As we'll learn with more clarity in the Anatomy chapters of this book, the "operating lever" of the Pectoralis major is the humerus (i.e., the upper arm bone). The origin of the Pectoral fibers are mostly on the sternum (aka "the sternal fibers"), with some additional fibers originating at the clavicle (aka "the clavicular fibers") and some on the lower ribs (aka "the costal fibers"). However, ALL the Pectoral fibers ultimately attach onto the humerus. Therefore, contraction of any of the Pectoral fibers requires the use of the humerus, as its **operating lever**.

One of the important questions to ask, when assessing this exercise, is "Does the operating lever of the Pectoralis major (i.e., the humerus), encounter a mostly perpendicular angle with the direction of resistance, during the range of motion?". In the exercise above (*Supine Dumbbell Press*), the answer is "yes". That "encounter" occurs when the humerus is parallel with the ground, in the descended position. This is one of the reasons why this exercise is a considered a "good" Pectoral exercise.

Is there a secondary lever in play here? Yes, the forearm is involved here, as a secondary lever. Is that lever more “active” than the primary lever, or is more “neutral”? It is more **neutral**, because it is mostly parallel with resistance, and that is also good.

Again, there are other factors which also help determine whether this is a “great” exercise or not. But the first thing to ascertain is whether or not the operating lever of the Pectorals (the humerus) utilizes lever efficiency somewhere in the exercise’s range of motion. It’s also important to ascertain whether another (non-target) lever is more active than the target muscle’s operating lever, because that would interfere with the loading of the Pecs.

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Hanging Leg Raises

(as an Abdominal exercise)

The primary objective of *Hanging Leg Raises* (shown above) is to work the abdominal muscles - specifically, the Rectus abdominis - also known as the Abs.

Is there an “active lever” here? Yes - it’s the femurs (upper leg bones). They (the femur bones) cross the point that is perpendicular with gravity when they’re horizontal. So the femurs are **active**. HOWEVER, the femurs are not the operating lever of the Abs. So, here’s a perfect example of the **wrong lever being the active lever**, during an exercise. The legs are being raised by a different set of muscles, known as the "hip flexors".

So, what is the operating lever of the Abs (as per the list above) ? It is the spine / torso / pelvis. None of these are perpendicular (active) during a Hanging Leg Raise. They are all parallel, or mostly parallel with gravity (neutral / mostly neutral).

In fact, the Rectus abdominis **does not even connect to the legs**, as you can see below. The Abs originate on the bottom of the ribs, and attach to the **pubic bone of the Pelvis**. When this muscle contracts, it brings the ribcage toward the pelvis. This requires flexion of the spine, and does NOT require flexion of the hip (as occurs during *Hanging Leg Raises*). Yes, there is a tiny bit of spinal flexion occurring during *Hanging Leg Raises*, but not much. More importantly, the spine is NOT interacting perpendicularly with gravity.

So, this exercise FAILS (miserably) in both of these criteria. Instead of the primary lever being most active - it is almost completely neutral. And instead of the secondary lever being mostly neutral, it's entirely active.

Hanging Leg Raises is a **very inefficient** exercise. In fact, it could be called "one of the LEAST efficient exercises" commonly performed in a fitness environment. The energy cost is very high, and the benefit to the Abs is very low.

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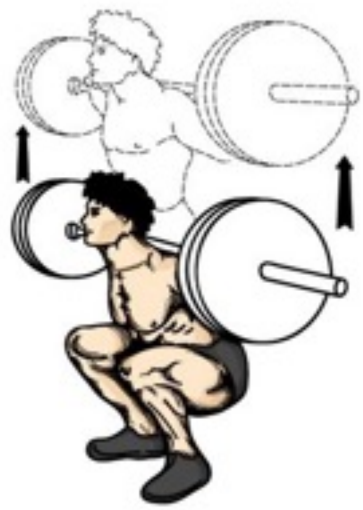
Squats

(as a Quadriceps exercise)



The primary objective of the Squats is to work the Quadriceps, followed closely **behind** (pun intended) by the Gluteus. So, the questions to ask here are, "How active are the Tibia (as the operating lever of the Quads) and the Femur (as the operating lever of the Glutes)? Also, is there any other (non-target) lever that is more "active" than it should be?

Let's look at the illustration below - which shows a nice side view of the levers in play - and examine the degrees of "perpendicular-ness" of those levers.

There are three levers in play here (excluding the foot) - the lower legs (Tibia), the upper legs (Femur) and the torso (spine).

In the illustration above, the Tibia is tilting forward about 30 degrees from vertical. Check this out for yourself, by simply placing a protractor over the figure. Line up the center of the protractor at the bottom of Tibia, near the heel. This translates to about a 33% tilt (30 divided by 90 degrees). We could, therefore, say that the Tibia is working with about 33% efficiency.

The Femur is clearly horizontal (perpendicular with gravity), so this lever could be called a 100% lever.

The torso is about 38 degrees. Therefore, we could say this lever is working with about 42% efficiency (38 divided by 90).

The higher the percentage of efficiency, the greater percentage of the "available resistance" that will be loaded onto the muscle that operates that lever. Keep in mind, however, that the "available resistance" also factors in the length of the lever.

For this reason, the Gluteus is not getting quite as much benefit (load) from a Squat as it would appear. Even though the Femur is 100% efficient (when in the descended position, like this), it is being effectively **shortened** by the "doubling back" of the Tibia (**the secondary lever**, as discussed in the previous chapter). So, the Glute is working with a femur that is operating with about half its actual length, in this scenario. Therefore, the femur is delivering 100% of a reduced load, to the Glutes.

Since the Tibia is only about 33% efficient, in the descended position of the Squat, it's only loading approximately 33% of the "available resistance", onto the Quadriceps.

Let's do a bit of math. Let's say a man is Squatting with 225 pounds on his back. His primary goal (*ostensibly*) is to work his Quadriceps. His bodyweight is 200 pounds, but only about 3/4 of that is the weight above his legs. So let's figure that he is effectively Squatting (225 + 150 =) 375 pounds. Since his Tibia (*length*) has a magnification factor of (*at least*) 20X, we'll multiply 375 by 20 (= 7,500 pounds) and then multiply that by his 33% lever efficiency factor. It brings it down to 2,475 pounds total (*divided by two legs*), which is 1,238 pounds per Quadriceps.

That may seem like quite a lot of load on each Quadriceps. However, as we'll soon see, it's not as much load as it could be, and the energy cost of that is higher (*ideally speaking*) than it should be.

The forward tilt of his **torso** has an efficiency factor (38%), which is higher than that of the Tibia (33%). His torso is also longer a lever, than is his Tibia, so it's magnifying resistance more. The barbell is resting at the very top of his torso lever, allowing the entire length of the torso to magnify the forward force of the 225 lbs. This means that his Erector Spinae (*the muscle operating the toro lever*) is loaded **more** than are his Quads.

A person is most likely to say that their goal - when doing Squats - is to work (primarily) their Quadriceps, (secondarily) their Glutes, with the least amount of strain on the back. However, in reality, their back is working the most. Their Quads and Glutes are working much less than they could be working, without the back strain.

Here's where we should ask, "Isn't there a way of getting a **greater percentage** of the available resistance on the **Quads**, and less on the Erector Spinae and the spine?". The answer is "yes". Simply change the direction of resistance (by using Cables, like below), so that the Tibia (lower leg) interacts more perpendicularly with resistance, than it does with "free weight gravity."

The photos above show a "Cable Squat". Notice that the added resistance is now coming from the cables, which are pulling in a frontward / downward direction. Of course, our own bodyweight is still being pulled straight downward. But for the sake of simplicity, let's just say that all the resistance is coming from the cable. Look at the photo above, farthest right. Notice that the Tibia is completely **perpendicular** with the cable. At that point, the Tibia is acting with 100% efficiency.

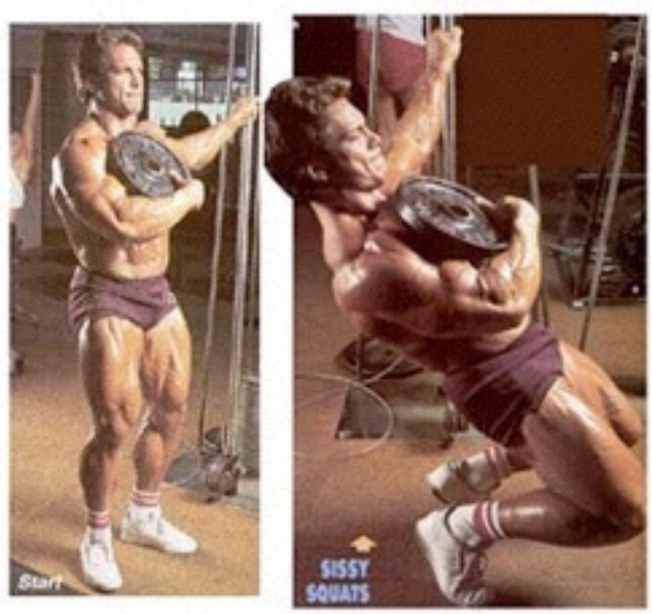
In addition to the Quadriceps getting 100% of the available resistance, there is very little downward loading on the spine. Certainly, there is no metal barbell pushing downward directly on the vertebrae. Further, because the cable handles are held low, the effective lever length of the torso is lessened, thereby causing less load on the Erector Spinae - which is also good.

This exercise will be discussed a bit more in Chapter 23 - the section which discusses Quadriceps.

For now, let's look at some other examples that utilize a fully active lever, rather than a 33% active lever.

Doing *Leg Extensions* (on a Leg Extension machine), and using only 150 pounds (75 pounds per ankle), would load each Quadriceps with 1,500 pounds (approximately) - precisely because the resistance is being applied to the Tibia perpendicularly. Compare that to the 1,238 pounds each Quadriceps is getting when Squatting 225 pounds, and consider the difference in "cost" between the two.

Below we see a couple of photos of Rich Gaspari doing an exercise called "*Sissy Squats*", while holding a 25 pound plate on his chest. 25 pounds is significantly less than the 225 pounds we used in the Squat example above. Yet, he's loading his Quadriceps **<u>more</u>** with THIS exercise, than the 225 pound Squat (above).



Rich's Tibia's are almost horizontal (almost **fully** "active") when he is in the descended position. He's about 5 degrees short of perfectly horizontal (assuming that is as deep as he goes, in this range of motion). So, his Tibia here has about a 94% efficiency.

Let's use the same formula as above, in regard to Rich's bodyweight (200 - 25% =), and use 150 as the bodyweight number. We'll add the 25 pounds he's using, so the total weight he's using as "resistance" is 175 pounds. We'll magnify that by the 20X figure (Tibia length), and then factor in the efficiency of 94% (175 x 20 x .94 =). That comes to 3,290 pounds, divided by two legs, equals **1,645 pounds per Quadriceps**.

That’s 407 pounds more (than the Squat example above) - which is 32% more load. But the “cost” here - with the Sissy Squats and a 25 pound plate - is significantly less. We used 375 pounds on the Squats, and only 175 pounds on the Sissy Squats. That’s **53% less** weight (or “**cost**”).

You see, the **reason** why a person is ABLE to Squat with so much weight (*sometimes as much as 500 pounds, or more*), is PRECISELY because of the **inefficiency** of Tibia angle (33%), combined with the shortened Femur length (*caused by the doubling-back of the lower leg*).

In a contest of who can move more weight, doing heavy Squats is like many of the other sports which measure output without regard to safety - like Pitching, Pole Vaulting or Shot Putting. But, for the purpose of building muscle, it would be much wiser to use better mechanics, load the target muscles MORE with less weight, and put LESS stress on the bones, joints and non-target muscles.

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When a Neutral Lever Is Made Dangerously “Active”

During the assessment of an exercise, we can use this concept (i.e., **active** lever versus **neutral** lever) to determine whether an exercise is efficient. However, we can **also** use it to determine whether an exercise has a potential risk of injury.

For example, in Chapter One we discussed the issue of the secondary lever, in regards to the Supine Dumbbell Press. We talked briefly about the internal and external rotation of the humerus, caused by allowing the forearm to tilt toward the head or toward the feet. Those were examples of “neutral levers made dangerously active”. During a Supine Dumbbell Press, the ideal position for the forearm is to have it be perfectly vertical (*neutral*), when viewed from the side.

Tilting the forearm **toward the feet**, causes the humerus to rotate “internally” (*toward the front of the body*), and forces the “external shoulder rotators” (Infraspinatus and Teres minor) to prevent further forward rotation. This could easily strain these smaller muscles, given the amount of weight that is typically used during a *Supine Dumbbell Press* for the Pectorals.

The same is also true for allowing the forearm to tilt **toward the head**, thereby causing the humerus to rotate “externally” (*toward the rear of the body*). This would force the internal shoulder rotator (Subscapularis) to prevent further backward rotation of the humerus, which could strain these smaller muscles.

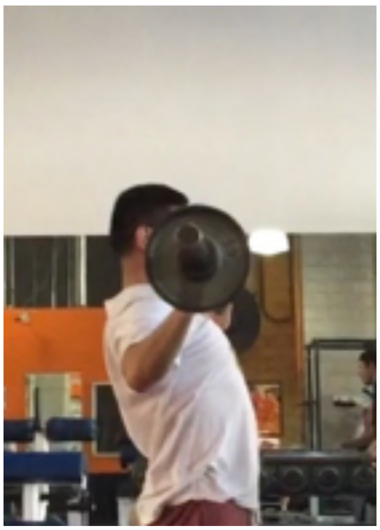
 

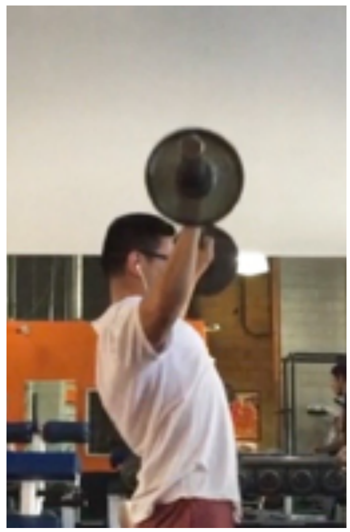
This (forearm tilt / humeral rotation) also happens often during Overhead Press and Incline Press exercises.

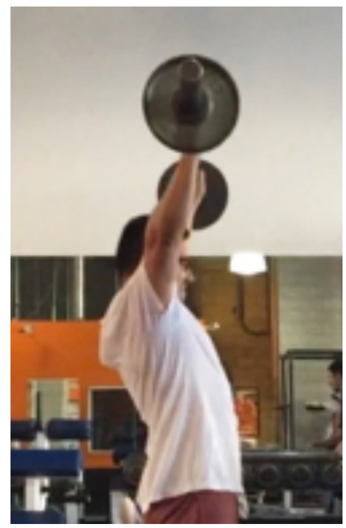
Below, we see a photo of Arnold Schwarzenegger doing a “Behind the Neck Press’, with a barbell. Notice that his right forearm (*actually both, but we can only clearly see the right forearm*) is tilting “externally” - toward the rear. This tilt is causing the forearm to be active with an external rotational force. Rotating the humerus to **this** degree (*even without weight*), inside the shoulder socket, is already very strenuous to the joint. Adding a heavy load onto one of the Rotator Cuff muscles further exacerbates the problem.

Overhead Presses have a other number of bio-mechanical shortcomings as well, which will be addressed in Chapter 21 (“Deltoids”).

Since the humerus attaches to the torso directly alongside the head (not in front of, nor behind the head), using a **barbell** automatically requires either a backward tilt to the forearms (for “Behind the Neck Presses”) or a forward tilt the forearms (for “In Front of the Neck Presses”) - so as to avoid hitting one’s self on the head with the barbell. Tilting the forearms either way (forward or backward) - during any kind of Pressing movement - strains the muscles of the “rotator cuff”. A backward tilt strains the internal rotators; a forward tilt strains the external rotators.







The photos above show this man tilting his forearm forward MOST in the far left photo, clearly to avoid hitting himself in the head. But even after the bar has passed his head, he still does not fully “correct” this forward tilt. As mentioned earlier, part of this is due to the fact that most people do not enough enough mobility in their shoulder joint, to rotate their humerus enough to cause their forearm to be perfectly vertical (during an Overhead Press). Either way, the result in the same. It strains the limits of external humeral rotation, and also strains the smaller, shoulder rotation muscles.

The Overhead Press would be “less bad” if the forearms could be kept perfectly vertical (neutral) - neither tilting backward nor forward. This could be done by using Dumbbells (instead of a Barbell) - assuming one has the shoulder mobility to achieve a perfectly vertical forearm position.

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Summary

A lever that is perfectly parallel with resistance (gravity, or some other direction, as caused by a cable, machine, etc.) is NEUTRAL, in the sense that it requires no effort from the muscles that operate it, to keep it in that position. It also provides no load whatsoever, to the muscle that operates it.

A lever that is perfectly parallel with resistance, could be defined as having one end either directly over, or directly under, its other end - relative to resistance. For example, a Lamp Post (below left) has its top directly over its base. It is not tilting in any direction whatsoever. A plumb line has its weight directly under its pivot (below right).

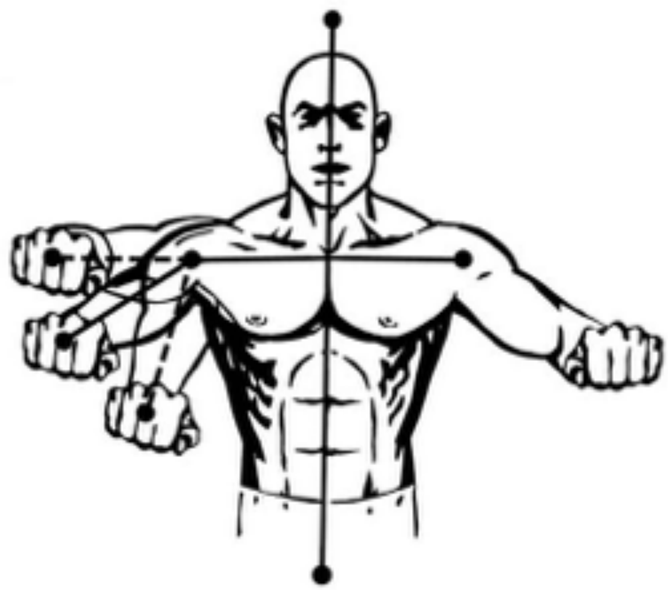
In fact, the reason a plumb line is used in construction, is to IDENTIFY the neutral position. Building are built so as to require the least amount of lateral support. Hence, they are built "parallel to gravity", using vertical columns, etc.

The human body operates the same way. All of our limbs are levers, and they follow the same rules of physics as any other physical object.

If we could view a lever from **directly** overhead - looking straight down onto it from above - while it is in its perfectly neutral position (parallel with gravity / resistance), it would simply look like a whatever is on top. Its base would be "hidden" under its top, or its top would be hidden under its pivot, if the lever is hanging down.

Likewise, when we are performing any type of Pressing movement (as one example).

If we could view a person from directly overhead, while he (or she) is performing a Supine Dumbbell Press, his forearms and elbow would be "hidden" behind his hand - because they would be directly under his hand, relative to gravity.



If he were to tilt his forearm outward (laterally…away from his midline) it would become active in one particular direction - loading his Biceps.

If he were to tilt his forearm inward (toward his midline) it would become active in a different direction - loading his Triceps.

If he were to tilt his forearm "internally" (toward his feet) it would become active in yet another direction - loading his Infraspinatus and Teres minor (external shoulder rotators).

If he were to tilt his forearm "externally" (toward his head) it would become active in yet another direction - loading his Subscapularis (internal shoulder rotator).

Of course, he cannot rotate IN and OUT at the same time, nor INTERNALLY and EXTERNALLY at the same time. But he can rotate OUT and EXTERNALLY at the same time, or any other combination. This sort of thing happens frequently.

So, when we are doing a Supine Dumbbell Press, it's important for us to ask ourselves (while we are doing the exercise), "is my elbow under my hand?". "Am I allowing my forearm to tilt out or in, externally or internally, or a combination of two possibilities?"

You will find that having your elbow under your hand is best, in terms of maximum power and efficiency, and also in terms of safety for the shoulder rotators.

It's difficult to ascertain this, when we cannot see ourselves. Sometimes, the view a mirror gives us is also not quite enough to see if a correction is necessary. A mirror cannot allow us to see ourselves from the side, or at least might be difficult arranging that sort of perspective. But we need to be aware of it, and try to FEEL for it.

Also, in terms of working with maximum efficiency, we should select exercises that allow the operating lever of our target muscle, to cross perpendicularly with the direction of resistance, during the range of motion of that exercise.

As pointed out above, that does not happen during *Parallel Bar Dips*, nor during standard *Barbell Squats* - and it compromises the efficiency of those exercises. A "better" version of a Triceps exercise would be a *Supine Dumbbell Triceps Extension*, and a better version of Quadriceps exercise would be *Cable Squats*, in terms of allowing the operating lever of the target muscle to be maximally **<u>active</u>** during the movement.

A maximally efficient exercise utilizes a fully active, or mostly active operating lever. Again, this is defined as a lever that interacts perpendicularly with the direction of resistance. When this occurs, the largest percentage of the weight being used, is loaded onto the muscle that operates that lever. Therefore, we find that we cannot use as much weight on those exercises, precisely because we are getting a larger percentage of the resistance, loaded onto the target muscle. Having to use less weight is a sign of efficiency. It means we are maximizing the load. We should not allow our ego to deter us from the exercises that prevent us from using huge poundages.

Conversely, an exercise that allows us to use a large amount of weight, does so precisely because it is minimizing the load to our target muscles. It typically does this my either using shorter levers (using bent arms instead of straight arms), or reducing lever lengths by way of a secondary lever, or by utilizing levers that are only working at 10, 20 or 30% efficiency (i.e., mostly "neutral" levers) - or a combination of the these.

For those who are pursuing muscular development, the wiser / safer / more efficient approach is to utilize maximally efficient levers, which magnify resistance more because they interact perpendicularly with the direction of resistance. This allows us to accomplish more, with less wasted (unproductive) effort and less risk.

Chapter Three

Mechanical Disadvantage

When a lever (i.e., bone) is positioned at an angle, such that a muscle is able to pull on it perpendicularly, it is called a "mechanical advantage". This is the most efficient angle from which a muscle can pull on a lever.

However, when a lever is positioned at an angle, such that a muscle is only able to pull on it from a mostly parallel position, it is called a "mechanical dis-advantage". This is the least efficient angle from which a muscle can pull on a bone. It requires significantly more force to produce limb movement, as compared with "mechanical advantage".

There are various angles BETWEEN perpendicular and parallel, from which a muscle can pull on its lever. These represent varying degrees of mechanical disadvantage and require increasingly greater forced, as the "disadvantage" increases.

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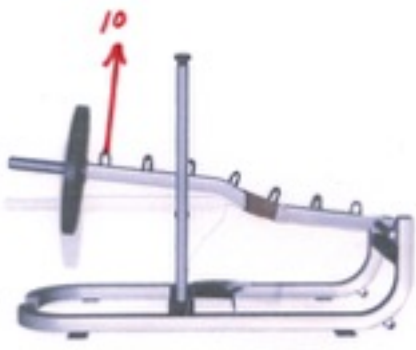
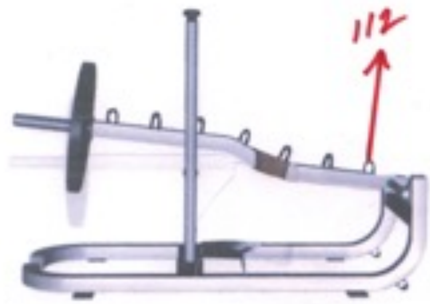
In Chapter One, I introduced you to a lever device I use to demonstrate the magnification effect of a lever (shown below).

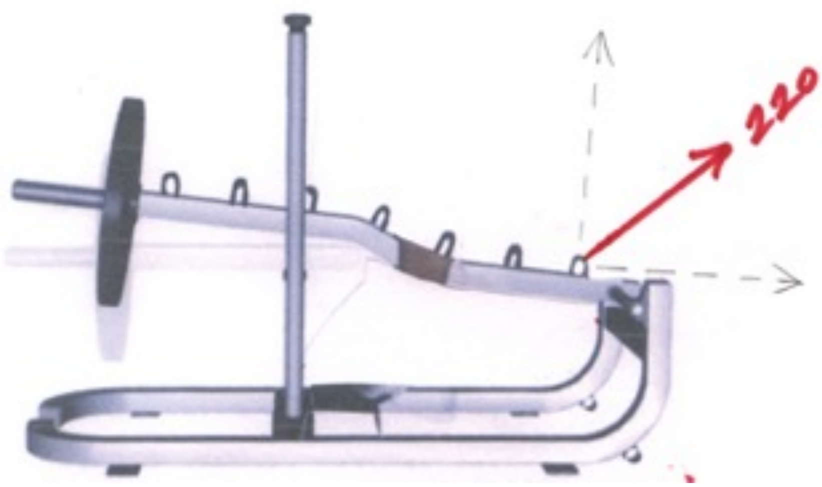
When I initially explained the experiment, I described how I went from the first hook on the device (the one farthest from the pivot) to the last hook (the one closest to the pivot). Each time I tested the force requirement, I pulled **straight upward** with the scale.

In fact, I was pulling in a direction that was perpendicular to the lever. The lever was horizontal, and I was pulling vertically. Thus, I was pulling from a **"mechanical advantage"**. The reason it is called "advantage" is because all of my effort is being used productively - to pull the lever in the direction it is able to move. There is no "better" (i.e., more economical) direction from which I can pull.





Now, in this next part of my demonstration, let's see what happens (in terms of force requirement) when I pull from a direction that is NOT perpendicular with the lever.



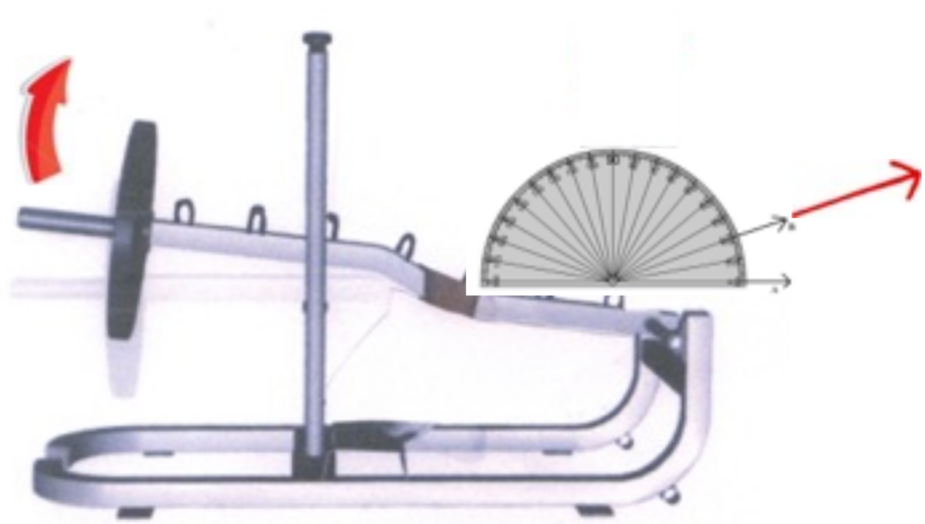
In the illustration above, the red arrow shows that I am pulling from an angle that is **halfway** between straight up, and straight IN (note the dotted lines) - from an angle that is in the middle between the perpendicular angle and the parallel angle, relative to the lever.

The scale shows that this direction of pull requires TWICE as much effort, as does a straight upward pull. Of course, there is still only a 10 pound weight on the end of the lever. The length of this lever magnifies that 10 pounds to 112 pounds, when pulling from a "mechanical advantage". Now, we see that that 10 pounds is **further magnified** by pulling on the lever from a 45 degree "**mechanical DIS-advantage**".

Any direction of pull that is less than 90 degrees (perpendicular) to the lever, will result in an increased force requirement. The force requirement increases proportionately, as the angle of pull approaches the parallel angle. The least force requirement is "straight up" (perpendicular with the lever), and the most force requirement is pulling from an angle that is parallel with the lever.

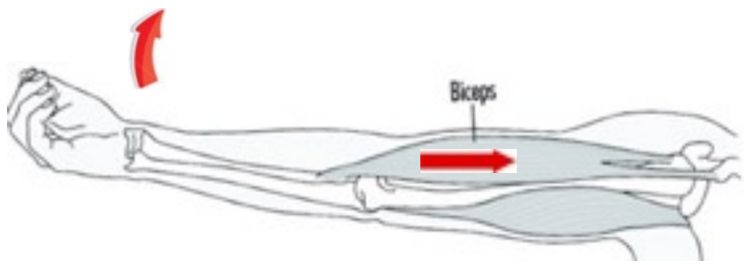
In order to calculate **approximately** how much force requirement there is, we'll use a simplified calculation involving percentages. When we pull from a 45 degree angle, we have to produce enough effort so that 50% of it equals the amount of our "straight upward" requirement (i.e., mechanical AD-vantage). The other 50% of our effort will be unproductively spent pulling the lever inward, toward the pivot. So, if 50% of our effort equals 112 pounds, then the total amount of effort (100%) will have to be (approximately) 224 pounds.

If we were to pull on the lever from an even "lower" angle - for example, 20 degrees (relative to the lever), as shown below - the force requirement would be significantly more. (illustration below shows a protractor measurement at 20 degree angle of pull)



20 degrees divided by 90 degrees = 22%. 100% - 22% = 78%. So, 78% of the effort being used when pulling from this angle, is going straight INWARD. 22% of the effort being used when pulling from this angle is directed upward.

If 112 pounds is 22%, than 100% is **509 pounds**. Think of that! If you put your arm, flat on a table top, and curled a 10 pound dumbbell **<u>from that angle</u>**, your Biceps would have to generate about 500 pounds of force, due to the **mechanical <u>dis</u>advantage**.



This may seem hard to believe, but it's true. This is a universal physics principle, which applies in all circumstances similar to this. Whether one is building a bridge or trying to build one's body, the concept of a mechanical DIS-advantage creating an increased force requirement is an absolute fact.

The calculation used above may not be perfectly accurate, but it's in the ball park. <u>What is important is to understand</u> that there is a much greater muscle force requirement when a muscle is forced to pull on its lever from a **mostly parallel angle**, as compared with the muscle pulling on its lever from a mostly perpendicular angle.

The above scenario is actually one which COMBINES two different resistance magnifications - a mechanical DISadvantage and a **maximally** active lever. One relates the angle of the muscle pulling on its bone, and the other relates to the angle of gravity pulling on the lever.

The muscle force requirement caused by a mechanical <u>**dis**</u>advantage ALONE would be much less, if the operating lever was mostly neutral.

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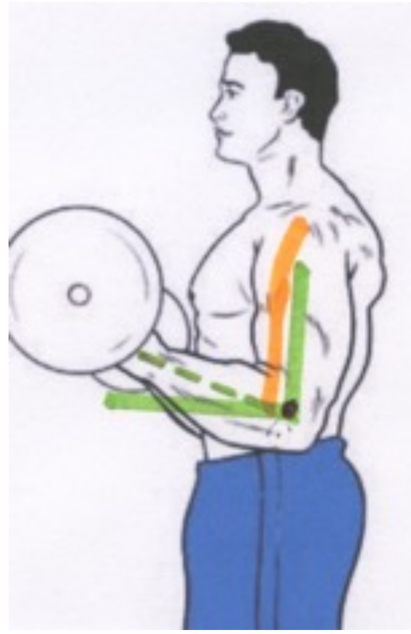
Application During *Standing Barbell Curl*

In the illustrations, we see a man performing a *Standing Barbell Curl*. I've drawn a GREEN line through his arm, indicating where his bones (levers) would be, and an orange line indicating where his Biceps would be. You'll notice that the muscle crosses the elbow joint, and attaches onto the Radius (one of the two forearm bones). When the muscle contracts, it shortens - thereby bending ("flexing") the elbow joint.

Most noteworthy, is how (in the photo above-left) the Biceps is pulling on the forearm from an angle that is mostly parallel to it. That shows a point of **mechanical DIS-advantage**. Then, when the elbow is bent (photo above-right), the Biceps is able to pull on the forearm from an angle that is mosly perpendicular to the forearm. That shows a point of mechanical Ad-vantage.

During any type of Biceps Curl exercise, the Biceps always goes through this sequence - from mechanical DISadvantage, through mechanical Advantage, and (assuming one goes beyond the elbow bent at 90 degrees) into a short range of more mechanical DISadvantage. Notice, however, that the mechanical DISadvantage that happens **after** the elbow bends beyond 90 degrees, that angle of pull is slightly away from the pivot, rather than toward the pivot. This is incidental, but still noteworthy.

What is VERY convenient, during a Standing Barbell (or Dumbbell) Curl, is that the point of mechanical DISadvantage (elbow straight) **coincides** with the point at which the forearm is mostly neutral. This means that when we have the greatest increased force requirement from the "disadvantage" (at the beginning of the range of motion), we have some relief in the form of a diminished force requirement from the mostly neutral forearm lever. Then, as the forearm lever increases its degree of "active" (more perpendicular with resistance), the Biceps gains a mechanical ADvantage, thereby providing some relief in the form of "economy". These two force requirements balance each other out.

"Mechanical DISadvantage" MEETS the "Active Lever"

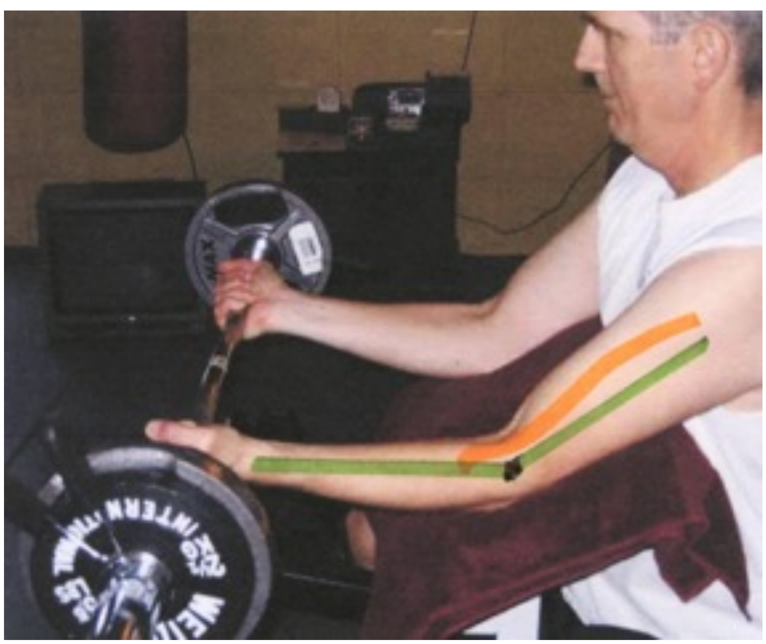
During a Standing Barbell Curl, mechanical DISadvantage conveniently meets with a mostly Neutral Lever. However, it doesn't always happen that way.

Have you ever wondered WHY ***Preacher*** *Barbell Curls* are so much **more** difficult than *Standing Barbell Curls*? Clearly, we can't handle the same amount of weight as when we're doing *Standing Barbell Curls*? Yet, it feels so "light" at the top of the movement. It's because the Biceps' angle of pull on the forearm (mechanical advantage / disadvantage) is not in sync with the resistance variations that occur during THIS type of Curl. They WERE in sync with the Standing Barbell Curl, above.

In the photo below, you can see that this man's forearm is horizontal, making it maximally **active** (lever is perpendicular with gravity). At the same time, notice that his Biceps (orange line) is pulling on his Biceps from a still mostly **parallel angle**. His Biceps is near its maximum mechanical **dis-**advantage, because of his "almost straight" elbow.

You'll recall (in the example earlier in this chapter) that this angle of pulling on a lever (approximately 20 degrees) resulted in an increased force requirement that was approximately **FIVE times** what it would have been with a 90 degree angle of pull.

In the exercise below, this 5X increased force requirement occurs simultaneous to when the forearm is most active ("heaviest"). In essence, he has TWO magnifiers of resistance occurring at the same time, at this point in the range of motion. Arguably, this is unsafe - especially if a significant amount of weight is used.



In addition, as most of us who have done this exercise know, when the barbell reaches the top of the range of motion (or close to it), it gets VERY easy. When the elbow is more fully bent, the Biceps gains mechanical <u>AD</u>vantage, because it able to pull on the forearm from a more perpendicular angle. But at the same, his forearm is entering a neutral position (relative to gravity), so the resistance is diminishing. We're getting "stronger", as the weight is getting "lighter", when we approach the conclusion of the range of motion. So, given the mechanics involved in **<u>this</u>** exercise, it provides too much resistance for our Biceps at the beginning of the range of motion, and not enough resistance at the end of the range of motion.

This is a good example of how a simple change of angle can drastically alter the benefit and/or risk to the muscles and tendons - sometimes for the better; other times for the worse. It nicely illustrates how theses two concepts sometimes help each other, and other times conflict with each other.

This Does <u>Not</u> Occur With Every Muscle and Joint

We primarily have **two** types of joint functions, excluding rotational joints.

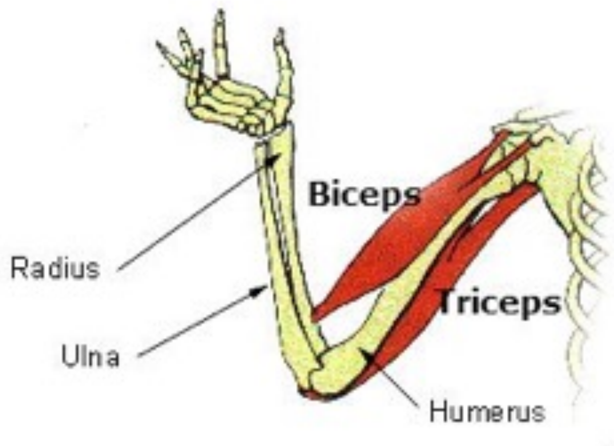
Some joints "bend" (*also known as a "flexion"*). In these cases, the joint angle decreases. An example of this would be the Elbow / **<u>Biceps</u>** joint function.

Some joints "open" (also known as "extension"). In these cases, the joint angle increases. An example of this would be the Elbow / **<u>Triceps</u>** joint function.

Only in circumstances where a muscle **flexes** (bends) a joint, can there be a mechanical **<u>AD</u>**vantage, somewhere in its range of motion. Those same joint functions also experience a mechanical **DIS**advantage (to varying degrees) somewhere else in the range of motion.

Joints that extend a joint **never** experience mechanical **AD**vantage. They always pull on their respective operating levers from a mechanical DISadvantage, because the joint angle never bends "toward" them. They never have an opportunity of facing their operating levers from a perpendicular angle.

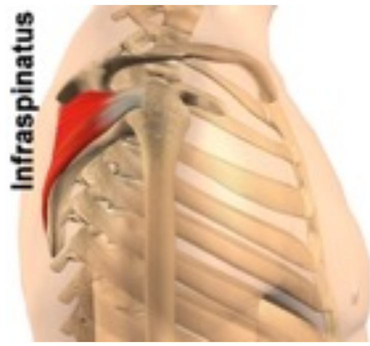
As you can see in the illustration below - with the degree of elbow bend shown - the Biceps is at a mechanical <u>ad</u>vantage. It is able to pull on the forearm from a perpendicular angle. However, the Triceps can **never** pull on the forearm lever from a mechanical advantage (perpendicularly). It can only pull on it from a mechanical DISadvantage, regardless of the degree of elbow bend.



An example of a joint that experiences mechanical ADvantage, but only a moderate degree of mechanical DISadvantage, is the ankle / calf / Achilles tendon. As you can see in the illustration below, the Achilles tendon pulls upward on the heel bone (i.e., the "Calcaneus" bone), from a mostly perpendicular position, most of the time.

Most of the large anatomical / skeletal movements can be classified as either flexion or extension - like the elbows, knees and shoulders. The other type of movement that sometimes occurs (briefly mentioned above) is "rotation". An example of this is the External Rotation of the humerus, which is caused by the Infraspinatus muscle.

In cases involving rotation, the angle of pull by the muscle on the bone could be classified as mostly a "dis-advantage", simply because there isn't much leverage on which to pull. However - even here - mechanical DISadvantage can be exacerbated. When the humerus (upper arm bone) is rotated while it's alongside the torso, the Infraspinatus muscle is able to pull its attachment on the humeral head directly TOWARD its origin on the inside edge of the scapula. However, when the humerus is held out, perpendicular to the torso, humeral rotation requires an angle of pull that is not directly toward the origin of the Infraspinatus, on the inside edge of the scapula. Thus, the DISadvantage created by this sort of situation also drastically increases the force requirement.



So, “mechanical advantage” and “disadvantage” are really descriptions of whether a muscle can, or cannot, pull on its attachment from a perpendicular angle - regardless of how we might classify the type of joint function.

The matter with which we should **concern** ourselves, is that combining a **mechanical disadvantage**, together with a **mostly active lever** (or some other type of very heavy loading) - in a given exercise - increases the risk of injury. Given that that is the concern, let’s identify the anatomical movements where each type of joint function occurs.

Joint Types: “Mechanical AD-vantage” and “DIS-advantage” in Anatomical Movements

The muscles / joints listed below are some of the primary ones that experience a degree of mechanical **ad**vantage, and **only** at certain stages in their range of motion. These are the joints that “**FLEX**” a joint (i.e., lessen the joint angle upon concentric contraction of the muscle that is causing that action).

1 the Biceps (Biceps brachii) / elbow
2 the Hamstrings (Biceps femoris) / knee
3 the Pecs (Pectoralis major) / shoulder joint
4 the Lats (Latissimus dorsi) / shoulder joint
5 the Forearm Flexors / wrist
6 the Abs (Rectus abdominus) / torso flexion / spine
7 the Calves (gastrocnemius) / ankle joint
8 the Tibialis anterior (front of the shin) / ankle joint
9 the Hip Flexors / hip joint
10. the Upper Trapezius / spine / clavicle / scapula

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The muscles / joints listed below are some of the primary ones that always operate with a mechanical DIS-advantage. These are muscles that "**EXTEND**" a joint (i.e., increase the joint angle upon concentric contraction of the muscle that is causing the action).

1 the Quadriceps / knee
2 the Triceps / elbow
3 the Forearm Extensors / wrist
4 the Paraspinals / Erector spinae / spine
5 the Deltoids (all three parts) / shoulder joint
6 the Gluteus / hip joint
7 the Middle Trapezius / spine / scapula

The muscles / joints listed in this second group have a range of motion that operates with the muscle pulling on the lever (mostly or always) from a mechanical disadvantage, and continues as such through the entire range of motion.

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Likelihood of Injury

Many of us have heard of people "tearing a Hamstring", "tearing a Biceps", or "tearing a Pectoral". Interestingly, those are all joint functions that "flex" (bend). For some reason, it seems that **most** muscle tears occur in joint functions where a muscle is able to experience both, mechanical Advantage and DISadvantage. And the injury almost always occurs precisely at the moment of greatest DISadvantage - when the muscle is fully elongated and the muscle is pulling from a mostly parallel angle.

Of course, it makes sense that a muscle would rupture at the point in the range of motion when the force requirement dramatically increases. Muscles that **extend** joints don't seem to rupture as often, even though they ALWAYS operate from a mechanical DISadvantage - or possibly for that very reason. Those muscles are accustomed to that greater force requirement. Conversely, muscles that experience both, operate with a wider range of force requirements, so they might not be as well-adapted to the higher forces.

Of course, it's generally true that all muscles are more vulnerable to injury when they are maximally stretched AND maximally loaded. The risk of injury (muscle tear) is not very high when we maximally stretch a muscle, WITHOUT load. But as we increase the resistance, the risk of injury generally increases in the **extreme parts of the range of motion** (i.e., maximum stretch and maximum contraction). But, a maximally stretched muscle that flexes its joint (i.e., Biceps, Pecs, Hamstrings, etc.), that is maximally loaded, combines the three risk factors.

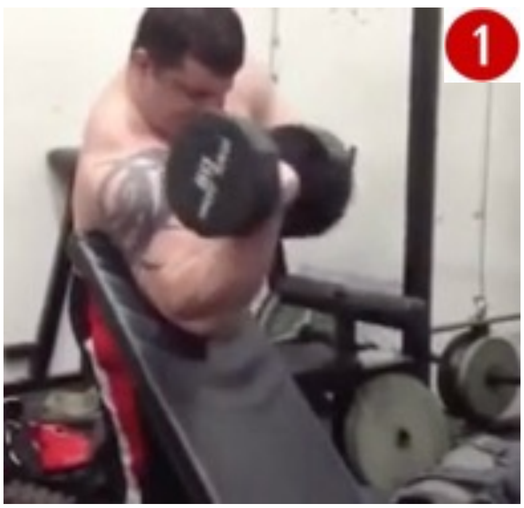
Let's look at some examples of muscle tearing during 1) exercise, 2) Power Lifts and 3) Arm Wrestling. We'll take note of which muscle is injured (whether it's a flexion muscle or an extension muscle) and what the circumstances were at the time of the tear.

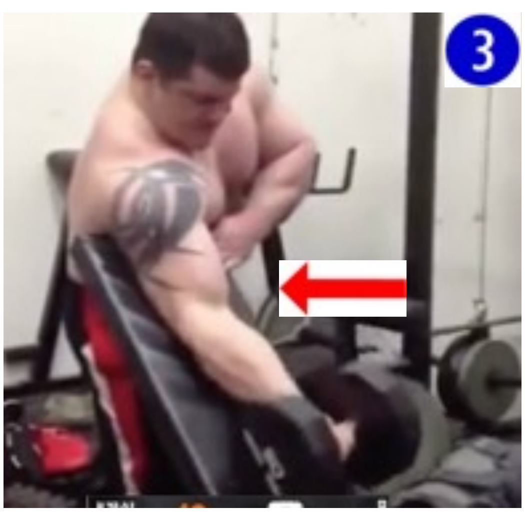
Biceps

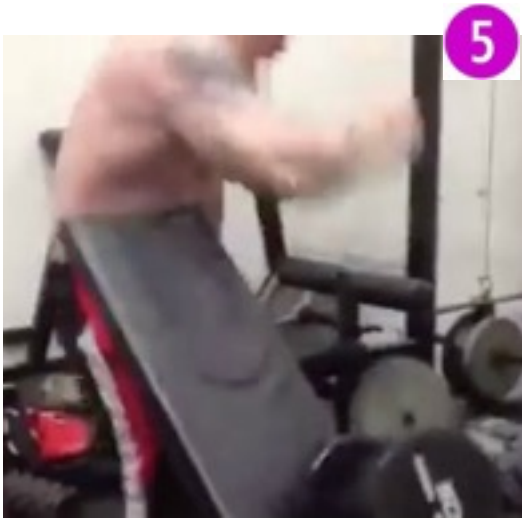
Biceps injuries (ruptures) are fairly common when **three** circumstances coincide:

1. Mechanical Disadvantage (elbow mostly straight)
2. Heavy Load
3. Palm of the hand facing upward

Let's look at the series of photos below, of this man doing a One Arm Preacher Curl.







In the first two photos, the exercise seems to going along just fine. However, notice what happens between the third and fourth photos. The distal (low end / attachment) of the Biceps has torn, and is suddenly “shorter” in the fourth photo, as compared with the third photo. In fact, this is the Biceps coming off its attachment on the forearm, and sliding up the arm, toward its origin.

You can also see a wince in the man’s face, at that moment. This is followed by him dropping the weight, cringing in pain, and grabbing his right Biceps. The Biceps ruptured precisely at the point in the range of motion where it entered the area of greatest mechanical DIS-advantage: the elbow nearly straight. Also, he had the palm of his hand facing upward.

The Biceps is one of the most vulnerable of all the “flexion” muscles. It’s worth noting, that the elbow is seemingly designed to be “flexed” (bent) by way of the Biceps AND the **Brachioradialis** - in combination. This may be especially true when the elbow is nearly straight.

In this illustration above, you can see this muscle crosses the elbow joint. It does not cross the wrist joint. Therefore, its only function is to assist the Biceps in flexing the elbow joint. However, it is only able to do this well, when the hand is held in a HAMMER grip position. When we turn the palm of the hand upward, the Brachioradialis is not positioned well enough to assist the Biceps in bending the elbow. The result is that the Biceps is left “un-assisted”, and apparently more vulnerable to rupture if overloaded.

Observe the following Biceps rupture, during a standard “*Dead Lift*”

In this series above, notice the difference between the second photo and the third photo. You can see the torn Biceps, sliding up the arm.

Once again, notice that the Biceps that tears during a Dead Lift, is the Biceps of the arm that has the palm of the hand turned outward. The Biceps that tears during a Dead Lift is never the Biceps of the arm that has the palm of the hand turned backward. Again, this suggests that turning the hand away (palm “up”) virtually eliminates the assistance and apparent protection of the Biceps, by the Brachioradialis. But also demonstrates the vulnerability of the Biceps when the elbow is nearly straight (mechanical Disadvantage) and heavily loaded.

When performing a Dead Lift, the forearm is mostly parallel with gravity - suggesting a mostly neutral lever. **However**, the poundages people lift during Deadlift is enormous - and while the the arms are theoretically supposed to be held “straight”, there is often an involuntary (subconscious) tendency to pull with the arms too. This results in bending that one arm, and loading the Biceps.

Also, the angle of the lever’s “perpendicular-ness” only determines the PERCENTAGE of the “available resistance” which is loaded onto the Biceps. So, if a man is Dead Lifting 500 pounds, the potential magnification of his forearm lever, combined with the **mechanical DIS-advantage** of a mostly straight elbow, could still result in a **2,700** pound load to the Biceps, EVEN if the degree of his forearm tilt is **only 5%.**

It is vitally important, when competitive Power Lifters perform their Dead Lifts, that they keep their elbows fully locked - so as to NOT engage the Biceps at all. My recommendation, for those who pursue Physique Development and feel compelled to do Dead Lifts, is that use “lifting straps”, and keep both palms facing down on the bar.

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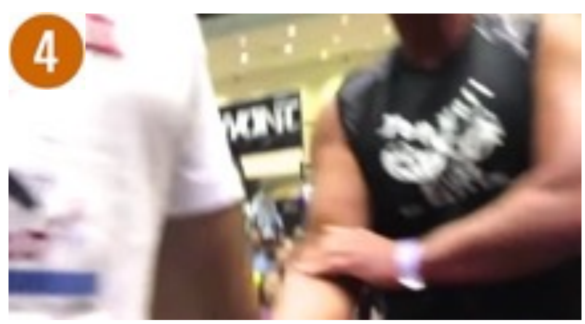
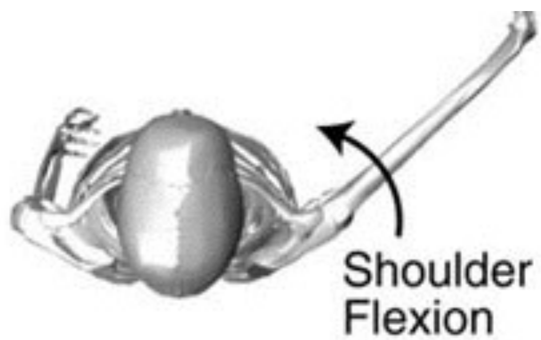
Here (below), we have a sequence of photos showing a man tearing his Biceps during an **Arm Wrestling Competition.**



In the first Arm Wrestling photo, the two men are getting their grips set. In the second photo, we see the man on the left, pull the other man's arm straight. Of course, the man on the right (with the black t-shirt) is resisting as hard as he can, with an extended elbow. Pop ! In the third photo, we see the torn Biceps sliding up the arm. And then we see him, in the fourth photo, holding his torn Biceps. Again, the 3 typical circumstances were present - the arm was nearly straight, the palm of the hand was turned upward, and the load was significant. It's somewhat predictable.

Pectorals

Another common injury of a "flexion" muscle is the Pectoral tear. This injury occurs most commonly in Power Lifting circles, during Bench Press competition - or in preparation of Bench Press competition. However, it also sometimes happens in Physique Development training, as well as "recreational" weight training, when people try to do a maximum weight Bench Press.



As you can see in the illustration above, the Pectoral muscles - which originate mostly on the sternum - stretch across the shoulder joint, and attach onto the humerus (upper arm bone), about an inch down from the humeral head. So, when the arm swings out laterally, the angle of Pectoral pull on the humerus is mostly parallel - which creates a fairly severe mechanical **dis**advantage. At the same time, the humerus is swinging to its maximally active position, when it's parallel with the ground (perpendicular with gravity). Of course, the heavier the weight used, the greater the risk.

It's also common for a person who is trying to Bench Press a maximum weight, to "bounce" the weight off his (or her) chest. In essence, this is a sudden reversal of the downward force. A sudden and uncontrolled **descent** of the barbell during a Bench Press, followed by a sudden reversal of the downward centrifugal force which has now been added, would further increase the load, as well as the injury risk.

But even those who are determined to use "good form" when doing a Bench Press, and refrain from using a weight that is "too heavy" (i.e., not fewer than six reps), may still allow their elbows to go "too low" (in the descended position), in an effort to touch the bar to their chest (assuming that's proper form). This excessive stretch at the bottom of the movement will exacerbate the mechanical disadvantage, and increase the risk of injury.

Let's do some simplified math on a **200 pound Bench Press**. It's worth seeing what happens when the humerus gets to the point where it's parallel with the ground - taking into account the **mechanical disadvantage**.

200 pounds divided by two arms is 100 pounds per arm. The humerus' length creates a magnification that is approximately 7X. The mechanical disadvantage, when the upper arm is parallel with ground is probably a factor of 6X.

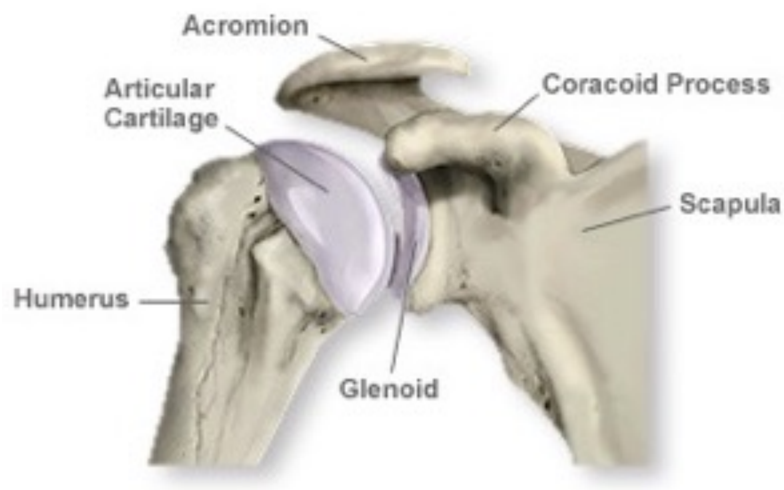
100 X 7 (=700) X 6 = 4,200 pounds

That's correct. While doing a Bench Press with a 200 pound barbell, the amount of force that (*one side of*) your Pectorals needs to produce is approximately **4,000 pounds** - at the point where the upper arm is parallel with the ground. You can do your own calculations related to Bench Pressing 315 pounds, 405 pounds or 500 pounds. When we understand how these numbers add up, we realize where the potential injuries are.

In addition to the risk of a Pectoral muscle or tendon tear, there is also some potential risk to the shoulder joint.

The **mechanical disadvantage** which occurs during a Bench Press, when the upper arm is parallel to the ground, is (*approximately*) a 5 to 1 ratio. This means that **<u>1</u>**/6 of the 4,200 pounds (*of a 200 pound Bench Press*) is moving the humerus upward, while **<u>5</u>**/6 of that force is pulling the humerus INWARD (*as the Pectoral muscle pulls from the sternum*).

This translates to (approximately) 3,500 pounds of INWARD force, pulling the humeral head tightly **against** the Glenoid socket of the shoulder joint.



Covering the humeral head is a layer of cartilage, and lining the Glenoid socket is the "Labrum". When these two (semi-soft) surfaces are pressed against each other with great force, the movement of the humeral head against the Labrum could eventually create enough friction (over time) do damage one or both.

Again, for those who's primary goal is Physique Development, this is not as much of a concern as it is for those who's primary goal is to lift maximum poundages. Physique Development training is not focused on lifting heavy. As was discussed in the previous chapter, it's more logical to maximize lever efficiency whenever possible. Using more **efficient** mechanics allows one to load a target muscle more, while lifting lighter weights. Loading a muscle more does not always require lifting **heavy**, when mechanics are used wisely.

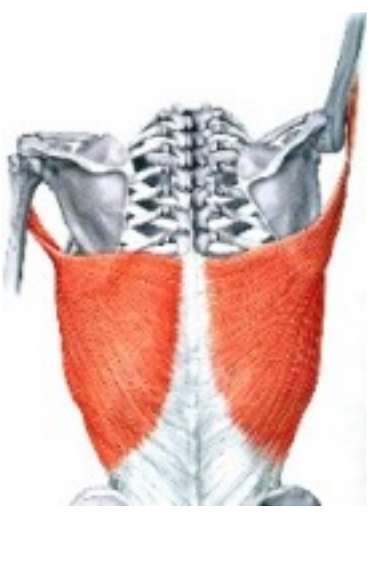
A torn Pectoral is a serious problem. Depending on the circumstances, it's not always possible to surgically repair it. The result of tearing a Pectoral and not having it surgically repaired immediately, could be some degree of loss of function, as well as Pectoral deformity.

Below are two photos of Francis Benfatto - a world class bodybuilder - before and after his right pectoral tear. For whatever reason, it appears he did not have this injury surgically repaired when it occurred. It's easier to re-attach a tendon onto a bone, than it is to repair a torn muscle. When a tendon breaks or comes off the bone, it only requires a singular re-connection. When a muscle tears, it may involve hundred of individual fibers, which is much more difficult to fix. That may have been the case here.

Latissimus dorsi

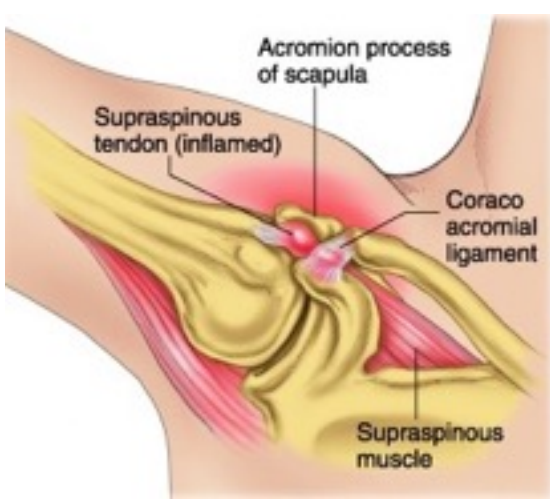
The **Latissimus dorsi / shoulder** is a also “flexion” joint function, which experiences mechanical advantage and disadvantage. Most of the time, however, they operate with an advantage.

As you can see in the illustrations below-left, this humeral angle would naturally create a mechanical **<u>Dis</u>**advantage, as the Latissimus is pulling mostly parallel on its operating lever. By the time the humerus is a bit lower, the Latissimus is able to pull on it from a more “economical” and safe angle.



The photo below below shows a man hanging from a Chinning Bar, with his arms straight up. Compare this photo, with the one above-left, and you can see that using this type of narrow grip ultimately results in a very dramatic “mechanical disadvantage”. Most people who have used this type of grip, can attest to the difficulty of getting out of that “bottom” position, as well as some shoulder discomfort.

There is also some degree of “shoulder impingement” risk with this type of (narrow grip) Chin-Up. “Impingement” is a pinching / squeezing of the Supraspinatus tendon between the the humerus (upper arm bone) and the “Acromion process”. This is the outer upper edge of the Scapula. The most common cause of “Impingement Syndrome” is putting one’s arms overhead frequently and repetitively.



The *Lat Pull-In*, shown below, is the much better option - as compared with Chin-Ups or Standard Pulldowns. It ensures that there is no impingement of the Supraspinatus tendon occurring. But, relative to this topic of this chapter, you can practically see (in the photo below-left) the Latissimus pulling on the humerus from a mostly perpendicular angle. This angle allows an excellent avoidance of entering extreme mechanical **Dis-**advantage (of the Lats). Yet, it's a complete Latissimus muscle elongation, providing full range of motion.

Hamstrings

Hamstring injuries are also very common, although not so much in fitness and Bodybuilding arenas. They tend to occur more often in sports such as Track & Field / Sprinting, Soccer, Football, etc., than in training for physique development. I suspect this is partly due to the randomness, suddenness, and unpredictability that exists on a playing field. Also, most "loading" of the hamstrings that happens on a playing field is related to incidence that occur when the leg is mostly straight.

Of course, the Hamstrings (aka “Biceps Femoris") is also a flexion muscle. When the knee is bent at 90 degrees, the Hamstring is able to pull perpendicularly on the Tibia. That would be a mechanical advantage. However, when the knee is straight, the Hamstring has to pull on the Tibia from an almost parallel angle to it, which is a mechanical **dis**advantage.

In daily activities - certainly in most “**running** / jumping” sports - it’s rare for the Tibia to encounter “resistance” against which it needs to contract, **while the knee is bent at 90 degrees**. Rather, the knee is usually only bent at approximately 10 or 20 degrees, when the Hamstring is required to contract against resistance. When that resistance exceeds the limits of the muscle or tendon, given the increased force requirement of a mechanical disadvantage, a rupture occurs.

In the photo below-right, we see a man sprinting. The back leg is pushing his body forward, mostly be way of hip extension. This requires force from the Gluteus and Adductors, but also from the Hamstrings. Yet, notice that the leg (knee) is straight. The other leg is bent, but it’s not yet loaded. It’s prepared to touch the ground, and when it does it will mainly load the Quadriceps. By the time the load transfers to the Hamstrings, the knee will be almost straight again (below-right).

In resistance training for physique development or muscular conditioning, we typically use a Leg Curl Machine to load and work the Hamstrings. Some people perform "Stiff Legged Deadlifts", but that is NOT a good strategy for Hamstring development. This will be further discussed in the Anatomy section.

Our goal is to develop the Hamstrings with the least amount of injury risk. Therefore, it would be wise to prevent the knee from going to the fully straight position, between reps - when performing Knee Flexion exercises (i.e., Leg Curls) on a resistance machine. This is especially true if there is still significant load at the point the knee is straight (i.e., the beginning of the range of motion). The "knee straight" position is where the greatest mechanical DIS-advantage occurs.

Some Leg Curl machines today have an adjustment that allows "limiting" the range of motion. One can set the machine to stop at the point where the knee is bent at 15 or 20 degrees - thereby allowing a better (stronger / safer) angle of pull by the Hamstrings on the Tibia.

In the photo below (taken in 1985), I was doing Prone Leg Curls on one of the older machines that did not have a "range limiter". So, I would place a piece of wood (a short "2 x 4") between the weights I was using and the weights I was not. This allowed me to stop at an approximate 20 degree knee bend (avoiding going to full straight knees). This degree of knee bend is my **starting** position, so as to avoid extreme mechanical DISadvantage on my Hamstrings, when doing heavy on Leg Curls.

One exercise that we see often in gyms these days, but which has a fairly high risk factor, is “Suspension Leg Curls” (for Hamstrings) - either on a ball or on some type of suspension straps.

Let’s do some math here. Assuming a person weighs 150 pounds, and they are suspending a third of their bodyweight by way of their feet / Legs, held in suspension straps - like the ones above. That’s 25 pounds per leg (50 is 1/3 of 150 pounds).

The length of the lower leg is approximately 17 inches (43 cm) - so that would be the first load magnifier. 25 pounds X 17 = 425 per leg. But that would be the load at Mechanical Advantage. When the legs are straight, as they are above-right, the Hamstring must pull on the Tibia from a **Mechanical DISadvantage**. A straight leg (10 to 15 degree angle of pull on the Tibia) would give us a multiple of (at least) 6X. So, 425 pounds X 6 = 2,550 pounds per leg.

This would be the approximate amount of force each Hamstring would have to produce, at the point the knees are street, using BOTH legs. Keep in mind, there is an amount of force that is essentially trying to hyperextend the knees (bend them beyond the "knee straight" position), and the only thing keeping that from happening (aside from the tendons and ligaments of the knee) are the Hamstrings.

What happens when we suspend a third of our bodyweight with just ONE leg???? The force required of the Hamstrings doubles. Is it wise to load a single Hamstring with over 5,000 pounds of force. Probably not.

This type of exercise (the two-legged version) might be acceptable for an athletic person who is under the age of 40 years old. But instructing a person who is 60 or 70 years old, to do an exercise like this, would be very imprudent. This would be made even worse, if the 60 or 70 year old person is overweight, and un-accustomed to exercise. Doing The one legged version would be taunting fate, at any age.

Summary

When moving a lever, Mechanical DISadvantage causes an increased force requirement because only a percentage of the force can be applied to moving that lever in the direction is must move. The angle of pull, during Mechanical Disadvantage has a compromised efficiency, because a portion of the force must be applied in a direction that is unproductive.

During exercise, Mechanical Advantage occurs when a muscle is able to pull on its operating lever perpendicularly, which only happens in cases which involve muscles that flex a joint. This includes the Biceps, Hamstrings, Pecs, Lats, Hip Flexors and a few others.

Mechanical Disadvantage occurs when a muscle must pull on its operating lever from an angle that is more parallel to it. This occurs in muscles that extend a joint, which includes Triceps, Quadriceps, Deltoids, and others. But it also occurs in muscles which flex joints, when the joint is maximally "open".

Caution should be used when performing exercises that combine a maximally active lever, a fully open flexion joint, and a heavy weight - like allowing the elbows to go fully straight during heavy Preacher Barbell (or Dumbbell) Curls, or the knees to go fully straight during heavy Leg Curls. These are among the most vulnerable moments in resistance exercise, because the increased force requirement of Mechanical Disadvantage plus a maximally active lever could easily overload a muscle and its tendon.

Chapter Four

The Resistance Curve

We know that an "active" lever is one that is perpendicular with the direction of resistance, and a "neutral" lever is one that is parallel with the direction of resistance.

A fully active lever (100% perpendicular with resistance) provides maximum load to the muscle which operates it; a fully neutral lever (100% parallel with resistance) provides <u>zero</u> load to the muscle which operates it.

The "Resistance Curve" refers to the variations of resistance that occur between zero and maximum, as the operating lever of a target muscles moves through the angles between parallel and perpendicular.

Understanding this concept, and all of its related features, allows one to select exercises that are more productive and more safe.

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The "**Resistance Curve"** is a term which refers to the sequential variations of resistance that occur through a range of motion, as a limb travels through the arc of a given exercise. Specifically, it identifies **where** - in the range of motion - the resistance is **more, most, less and least**.

Muscles typically have a "**strength curve**", which determines where (in the muscle's range of motion) it is stronger and weaker. Ideally, an exercise's "resistance curve" should match (more or less) the "strength curve" of one's target muscle. It is obviously less beneficial for a muscle to encounter very little resistance where it is strongest, or "too much" resistance where it is weakest.

Also, an exercise should provide some degree of resistance through the muscle's **entire** range of motion. However, if an exercise's range of motion crosses an "**Apex**" or a "**Base**" somewhere in the middle of the muscle's range of motion, than the value of the exercise is greatly diminished. The "Apex" and the "Base" are the "neutral" points, when the lever is either pointing straight upward or straight downward. In either case, the lever would be parallel with resistance, and therefore "neutral".

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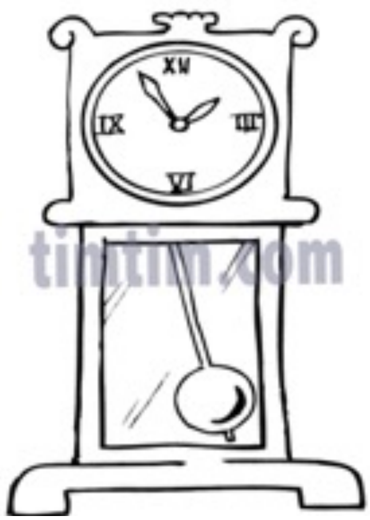
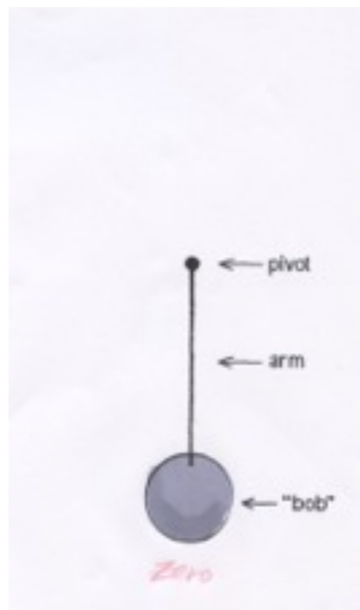
Imagine that we are standing in front of a large **pendulum**, like the kind that is typically used in a Grandfather Clock.



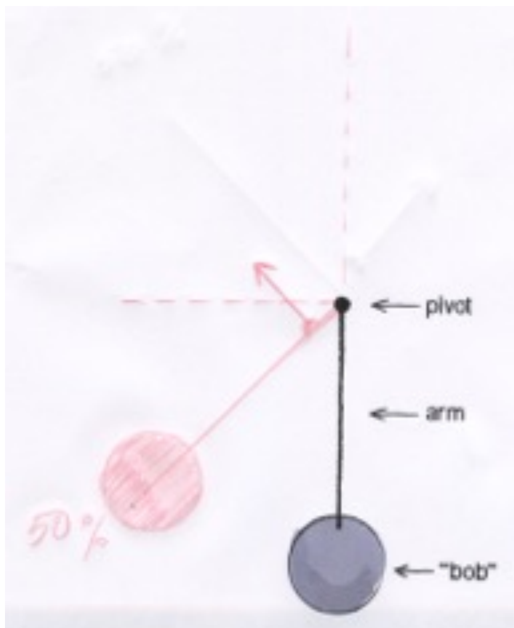


Like any pendulum, it has a PIVOT, an ARM and a WEIGHT - sometimes called a "bob". Let's suppose this pendulum (illustration above-right) has not been moved by the clock, nor by any other force. It is just sitting there motionless. It is not swinging. It is simply hanging straight down, balanced under its pivot.

The reason it is not moving is because - as we learned in Chapter Two - a lever that is parallel with resistance is neutral. It requires no effort to stay in that position. This position could also be called the "zero" position, and it could also be called the "Base". The "Base" position is the "lowest point in the lower half of a circle". It is also the position which has its "bob" (weight) closest to the source of resistance - in this case, gravity.

For the sake of analysis, let's say that the weight on the end of this lever ("arm") is 10 pounds. And, for the sake of consistency, let's say the length of the lever arm is 12 inches - like the forearm lever we used in the Chapter One. So, when this lever arm becomes "active", it will have the same magnification (12 to 1) that the lever in the first chapter had.

We'll walk up to this lever, and pull (or push) it to the left, with a force that is perpendicular to the lever arm. We would, therefore, be pulling it with a mechanical <u>ad</u>vantage. We'll move this lever to a position that is **half way** between the vertical position and the horizontal position - to a 45 degree angle.

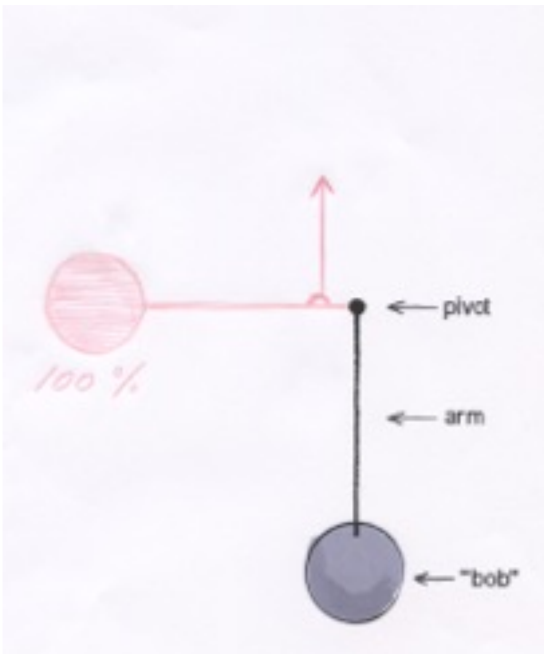


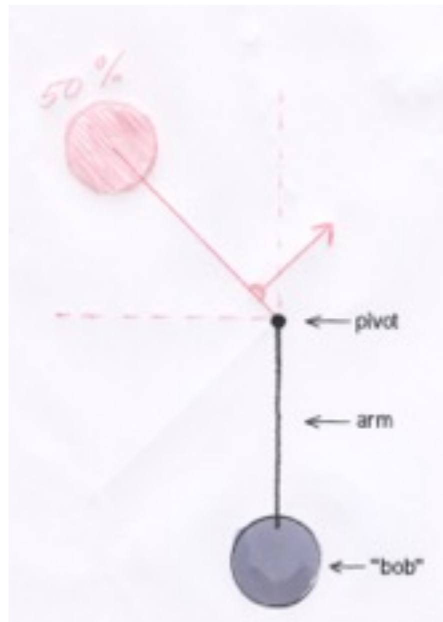
As you know, the horizontal position is the 100% "active" position. We are now **half way** between vertical and horizontal position. So, we are going to call this the "50% position", although a trigonometry calculation would reveal a slightly different number. The purpose of this book is to gain a **broad** understanding of resistance exercise - it is not to learn advanced mathematics.

We have already defined the "available resistance" as being the weight held in the hand (attached to the end of the lever), magnified by the length of the lever, multiplied by whatever mechanical disadvantage there happens to be, if any. Here, with the "force" arrow pointing **perpendicularly** from the lever, there is no DIS-advantage. We only need concern ourselves with the other two factors - lever length and lever position.

As per the numbers we used in Chapter One - we know that a 10 pound weight resulted in a 112 pound force requirement when the lever is perpendicular to gravity. Therefore, a 45 degree (diagonal) lever results in (approximately) a 66 pound force requirement, in order to hold the lever at this position. This would be **half the amount of resistance**, because we are half-way between zero and maximum. Of course, this "force requirement" is based on the force ("F") application (indicated by the red arrow) being in the same place on the lever as it was in Chapter One (one inch away from the Pivot).

Now, we'll push the lever farther up (below-left), so that it is at the perpendicular position. Again, this is the 100% position. So, we are back to 112 pounds of force required, in order to hold the lever arm at this angle.



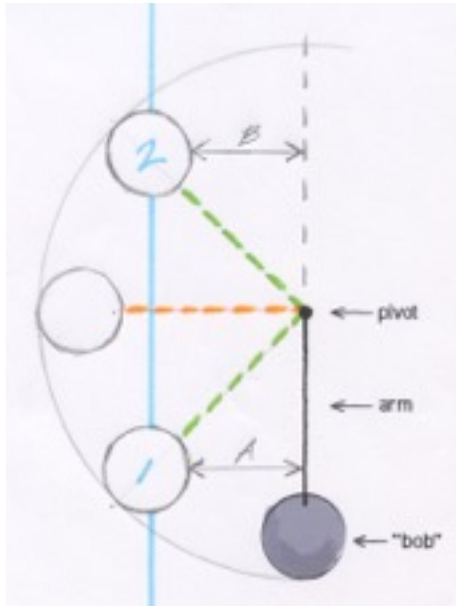


We then continue to the next step in our "experiment", moving the arm to a 45 degree angle, but on the upper half of the protractor (above-right). Here again, we are half-way between the horizontal and vertical positions. So, the force required to hold the lever arm at this angle is 66 pounds - again, 50% of the "maximum" position.

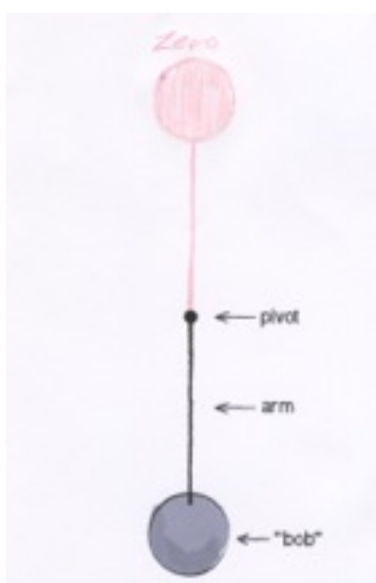
As you'll notice, it does not matter whether the lever is on the upper half or the lower half of the "circle". A 45 degree angle is the same in either case (assuming no momentum / swinging has been created). The reason for this is that the force required is based on the distance from the weight to the pivot, with vertical lines drawn. That distance is the same, regardless of which half of circle (upper or lower) the lever is.

In the illustration below, focus your attention on the "bobs" labeled 1 and 2. As you can see by the pale blue line drawn through them, that their distance from the Pivot (identified by the dotted vertical line), is the same. Distance "A" is the same as distance

“B”. Therefore, each position would have the same amount of downward force, assuming no momentum (swinging) has been added.



Now, In the photo below, we have moved the lever arm to the **neutral** position that is on the upper half. This position is called the “**Apex**”. It is characterized as being the highest part of the arc. It is the neutral position that is **farthest** away from the source of resistance. The lever is in a zero position again, because it is balanced **over** the Pivot.



This is the **resistance curve** - the sequential variations of resistance that occur through an arc, as a lever moves through the different angles between parallel with resistance, and perpendicular to it. When a lever is 25% between parallel and perpendicular, the force required to hold the lever at that position, is also (approximately) 25% of what that force requirement would be when the lever is at 100% - all other factors being equal.

Note: Once again, our purpose here is not to teach Trigonometry - the formula that "should" be used to calculate these sorts of vectors. Our purpose here is to gain a broad understanding of the sequential changes in resistance that occur in resistance exercise, as a lever moves through various angles of resistance.

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All exercises have a different resistance curve - depending on the source (direction) of the resistance AND your body's position in relation to the direction of resistance. More importantly, **NOT all resistance curves are equally productive, nor equally safe**.

There are various TYPES of resistance that play a role in resistance exercise, and they each have a unique set of characteristics associated with them. Without understanding these characteristics, it is impossible to accurately define the resistance curve of an exercise.

For example, although the two exercises below utilize the same type of bench, the same seated position on that bench, and the same movement, each of the two exercises below have a **different** direction of resistance. Each utilizes a different source of resistance, and each source of resistance behaves differently. One involves free weight gravity, which always pull straight downward, creating parallel lines of resistance, as the forearm moves through its arc. The other involves a cable, which always pulls toward the pulley, creating fan-shaped lines of resistance, as the forearm moves through its arc.

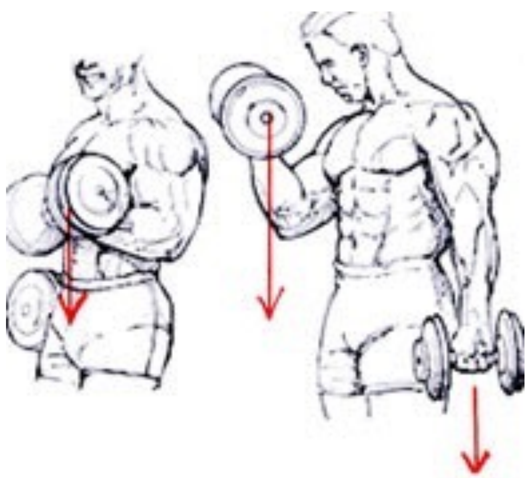
One of the exercises above is “very good” (optimally productive and safe), the other is not so good (less productive and less safe).

Types (and Directions) of Resistance

There are at least **eight** “types” of resistance, typically used in resistance exercise. And, for the most part, they each create a unique resistance curve.

1. “**Free Weight” Gravity:** Dumbbells, barbells, and bodyweight exercises (e.g., chin-ups, pushups, parallel bar dips, TRX, etc.) - will result in a resistance curve that is precisely like that of the pendulum described above. The reason for this is that free weight resistance **always** results in a **“straight down”** **<u>direction</u>** of resistance. We cannot SEE gravity, of course, but we **know** that it always pulls STRAIGHT down. This is why we use a “plum line” to determine what is vertical, when constructing a building or other structure.

At any point in the range of motion of an exercise, we can imagine a vertical arrow, pointing straight down, from where ever the weight is. A **horizontal** lever (*i.e., limb*) will therefore always be “perpendicular with resistance”, when dealing with “free weight gravity” - because gravity is always vertical.

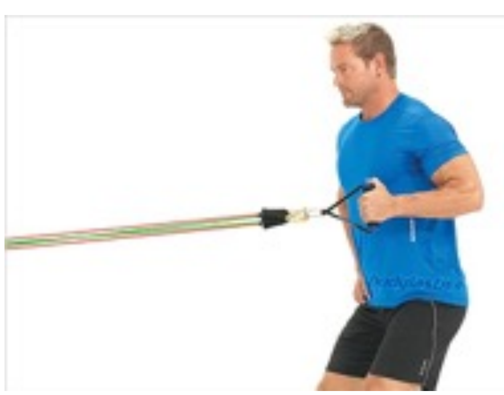


2. Cable exercises: Cables produce a direction of resistance that follows the angle of the cable. So, if the cable is pulling to the left (*horizontally*), rather than straight down (*vertically*), the resistance curve will **not** be measured vertically - the way it would be with a pendulum. The cable essentially RE-DIRECTS the direction of gravity. For example, it may come from above us (*like in a Lat Pulldown*), because that’s where the pulley is. A lever (*i.e., limb*) that is perpendicular with the CABLE, will be a 100% lever.

In the photo below (*Lat Pulldowns*), we can see that the weight stack on the machine is being pulled downward by gravity. However, the cable re-directs the direction of resistance to the user of the machine, such that it creates an UPWARD direction of resistance for him, against which the user must pull downward. Therefore, the direction in which the cable is pulling, would be used to identify the resistance curve.

3. <u>Elastic bands</u>: These are similar to cables, in the sense that the direction of resistance is coming from the location of its origin. However, unlike cables, resistance provided by elastic bands is not consistent. It increases as the band is stretched farther.

Calculating the actual amount of resistance that is provided by an elastic band - at any point in the range of motion of an exercise - is **much** more complicated, because one has to know how much the resistance is increasing due to the elastic stretch, PLUS the angle of the limb relative to that resistance.



Certainly, elastic bands are convenient. They are light-weight and very portable, so they allow a person to do a type of resistance exercise where ever they happen to be. However, they are NOT ideal, from the perspective of building muscle.

Again, muscles have a “strength curve” which usually cause them to be stronger when they are elongated, and LESS strong when they are contracted (*shortened*). So, the ideal resistance curve of an exercise would be such that it provides MORE resistance when the muscle is elongated, and LESS resistance when the muscle is contracted. **Elastic bands do the opposite.** They load the muscle less when the muscle is elongated (i.e., stronger), because the elastic band has not yet been stretched. Then, they load the muscle more as the muscle is shortened (i.e., weaker), because the band is increasing its length and tension.

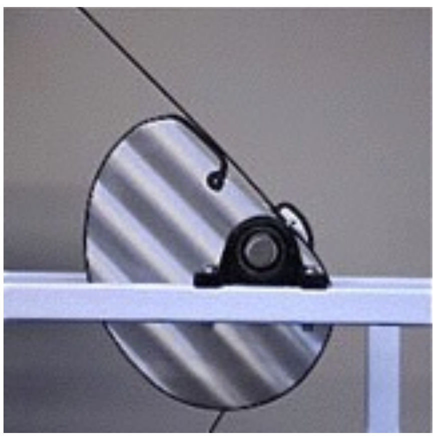
This is a very unfortunate aspect of using elastic bands as the source of resistance, in exercise. This “backward” resistance curve (*regardless of angle*), is less than optimally productive for muscle building, and is also LESS comfortable, to a degree. Using elastic bands tends to leave you wanting more resistance where you're stronger (*in the early phase of the range of motion*), and wanting LESS resistance where you’re weaker (*in the latter phase of the range of motion)*.

Still, it’s important for us to understand the factors involved in the resistance curve of elastic bands, as they do represent one type of resistance exercise.

4. Machines that have a <u>circular</u> cam: - This type of machine provides an even (*non-varying*) amount of resistance, throughout the entire range of motion of a given exercise.

An example of this type of machine would be a Multi-Hip Machine (shown above), with a cam that is **perfectly circular** - rather than oblong. This causes the cable that is riding on that cam, to always be the same distance from the cam's pivot. This results in "unchanged" resistance, regardless of where the person's limb is, in the range of motion.

5. Machines that have an <u>oblong</u> cam: This concept was first introduced by Arthur Jones, the inventor of the original *Nautilus* machine. In fact, the logo for his brand was a (Nautilus) sea shell, because it has an oblong shape. With this type of machine, the resistance increases when the cable rides along the wider part of the cam, and then it decreases when the cable rides along the shorter part of the cam.



Arthur Jone's theory was that a machine that "matched" its resistance curve, with the **strength curve** of the target muscle, would be more effective at building muscle. Theoretically, that is correct. However, sometimes the resistance curve of a particular NAUTILUS machine did not match the strength curve of the target muscle. Other times, it neglected to account for any mechanical DIS-advantage that may be occurring (in a given joint) at the beginning of the movement. And lastly, **<u>not</u>** all Nautilus machine's **movements** were anatomically "ideal". In short, NAUTILUS machines did not revolutionize the Gym Equipment Industry, as much as some people expected it might. They did not build muscle better than other methods of resistance exercise, and they did not always feel "natural", in terms of motion (although some were very well designed).

In general, "resistance machines" are especially popular among people who are unfamiliar with exercise, because they are easy to use ("self-explanatory"). However, from the prospective of "optimal physique development", they are often not quite as good as the equivalent exercise performed with either free weights or cables - generally speaking. Leg Extensions and Leg Curls are two notable exceptions, if only because it's impossible to grip anything with the feet, the way we can with our hands.

Any kind of “resistance machine” typically requires adjustment for individual height and/or limb-length, as well as correct positioning in the machine. If a person is able to achieve the proper adjustments and body position on the machine, the effectiveness is optimized. However, incorrect height and/or limb-length settings, and improper body positioning on the machine, diminishes the potential effectiveness of these machines.

6. Machines that carry the weight on a lever arm: With this type of machine, plates are loaded onto a lever arm on the machine. Therefore, instead of using one’s own limb (a forearm, for example), and observing where it crosses perpendicularly with gravity - here **we observe the lever arm of the machine**, and see where IT crosses gravity. Of course, the angle of machine’s lever arm may, or may not, be designed “properly” - meaning that it might create an ideal resistance curve, or a compromised resistance curve. We cannot assume that all machines are designed properly. This “lever-loaded” concept is generally good, provided it is designed correctly.

In the photo below, observe that the weight is loaded onto a lever arm behind the user. The angle demonstrated at this precise moment, is that the lever arm is rising FROM the maximum position (perpendicular with gravity), so the resistance is diminishing as the Lat muscles contract. This is generally good - even if though movement itself is less than ideal.

In the exercise below, we see that the weight is loaded onto a lever arm that is at a different angle than that of the user’s forearm. This is “good”, because of the mechanical DIS-advantage that occurs in the Biceps, during this movement. We want the resistance to diminish SOME when the elbow is almost straight, since the “disadvantage” will automatically increase the force requirement. The particular resistance curve shown here is not quite “ideal”, but it’s fairly good. It would be better if the machine’s weight bearing arm was more vertical when the elbow is fully extended.

7. Machines that carry the weight on a Sled or Carriage: Rather than moving a weight through an arc, these machines moves resistance through a straight line, but usually at an angle. Examples would be the 45 Degree Leg Press (below-left) and the Angled Smith Machine (below-right).

Here, the direction of resistance is the same as the sled's line of travel, parallel with the guide rods of the machine. Any lever (limb) that crosses **perpendicularly** with THAT direction of resistance, would be at a **100% lever**. Any lever that is **parallel** with that direction of resisted, would be **neutral** - or nearly neutral.

As you can see in the Leg Press photo above, the Tibia (lower legs) are nearly parallel with the machine's guide rods (which indicate direction of resistance). Therefore, the muscle which is operating his Tibia (i.e., the Quads) will not get much work here, since its operating lever (the Tibia) is a nearly neutral lever during most of the range of motion (using the foot positioning shown here). The Femur is more perpendicular with resistance, which means the Glutes will be much more loaded than the Quads.

One thing that should be noted with this type of machine, is that the ACTUAL amount of weight ON the machine is **never** the amount that is LOADING the body, due to the **diagonal** angle of the "sled". Only a percentage of the full amount, relative to the degree of the angle, will load the body. The more vertical the angle, the closer to 100% that would load the body. The more horizontal the angle, the more of a reduction in the actual weight that occurs.

For example, a carriage (Leg Press or Smith Machine), running along guide rods that are perfectly **vertical** (no angle at all), will result in 100% of the weight bearing downward.

Conversely, if a person were using a machine who's carriage ran along guide rods that were 100% **horizontal**, there would **zero** downward force provided. Of course, there is no such machine, for this very reason.

(Note: There are machines that have a platform that travels horizontally, however the resistance they employ comes either from a cable / pulley, or from springs (as in a Pilates Reformer) - not from free weights stacked onto a sled, like that of a 45 degree Leg Press.)

A “45 degree Leg Press” would provide the user with a diagonal force that is approximately half of what is actually on the sled (45 degrees being half way between vertical and horizontal). Technically, the amount would be closer to 70%, when calculated using the appropriate Trigonometry formula. But, again, the goal here is **not** to become mathematicians. It is to gain a broad understanding of how the mechanics of resistance exercise works - and that includes knowing that an angled sled (of sorts) automatically results in a reduction of the actual load, to some degree. It’s also important to know that the “**direction** of resistance” is represented by the guide rods of the machine.

8. Pilates Reformer: Pilates is not usually considered a “physique development” type of exercise. Nonetheless, there is resistance at play here, and it follows the same rules.

As is the case when evaluating ANY resistance exercise, the first consideration is the line of pull (i.e., the direction of resistance). Similar to cables and elastic bands, with a Pilates Reformer, we can **SEE** the line of pull. It is the rope, coming from the pulley. That is the first clue as to what the resistance curve is during the various exercises performed on a Reformer.

The direction of resistance **also** informs us which muscles are loaded (or not). As we'll explore more fully in Chapter 6 ("Opposite Position Loading"), **whatever muscle is positioned directly opposite the line of pull** (i.e., the direction of resistance) **will be most loaded**. So, it's critically important that the "line of pull" is loading the muscle(s) you WANT to load, and not loading muscles you have no intention of loading.

When assessing Pilates, or any other exercise, we need to ask the following questions:

1. Is that particular movement of the body, "natural"? In other words, is this movement consistent with the primary functions of the muscles and joints involved? This will be further explored in the Anatomy section of this book.

2. Is the Resistance Curve maximally productive? Does it provide more resistance where the muscle is strongest, and less resistance where the muscle is weakest?

3. Is the Direction of Resistance coming from an angle that is directly opposite the muscle we want to target. As we'll learn in Chapter 6 ("Opposite Position Loading"), **only** the muscles that are positioned directly opposite resistance will be gain maximum benefit from that resistance.

Many Pilates exercises fall short in one, two or all three of these categories. The movements (exercises) were obviously created to accommodate the design of the machine (notwithstanding the machine's limitations), as opposed to having the machine designed to conform to the natural functions of the anatomy. Yes, most of exercises performed on a Reformer DO have some degree of benefit, but they are often less than "ideal", in terms of anatomical function.

Also, the Resistance Curve of virtually all Reformer exercises is arguably "less than ideal", due to the fact that resistance comes mainly from springs, underneath the carriage. Springs - like elastic bands - increase their resistance as they stretch, and decrease their resistance as they are allowed to shorten. Again, this is the opposite of a muscles' natural strength curve. This does not mean the resistance provided by the Reformer is has no value. It is simply not quite in sync with the body's natural strength curves, so it's less than maximally productive for muscle development.

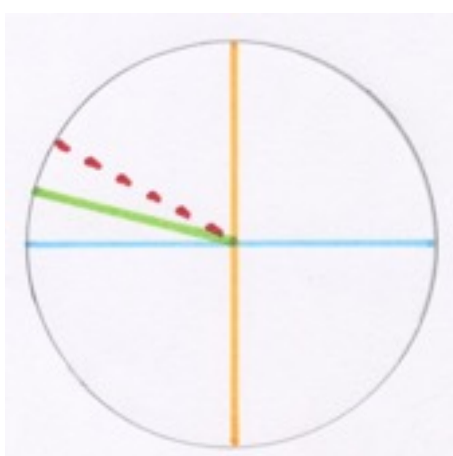
Lastly, the Direction of Resistance, on a Reformer is fixed (not adjustable). It comes from the small pulleys attached to the extenders. These extenders cannot be set higher, or lower, nor farther back, nor farther forward, nor farther apart. This limitation inhibits the ability to target the muscle one wants to target, and forces other muscles - likely NOT the intended target of the exercise - to be loaded instead.

The direction of movement, and the direction of resistance, are VITALLY important in the determining the value of an exercise.

Manipulating the Resistance Curve

We know that a **perpendicular** lever (i.e., limb) will load its operating muscle with 100% of the available resistance, and that **parallel** lever will load its operating muscle with ZERO resistance. We also know that a lever that is between those two points will load the muscle with a commensurate percentage of the load. For example, if the lever is **half-**way between being perpendicular with gravity, and parallel with gravity, it will load the muscle with approximately **half** of the available resistance.

In the illustration below, I've drawn a green line at the 15 degree mark. The red-dotted line shows the 30 degree mark. The pale-blue line shows the perpendicular position. Let's say we have a 100 pound lever, and we want to know how much load will be put onto its operating muscle, when that lever is at the 15 degree mark, and at the 30 degree mark. Let's do some simple math.

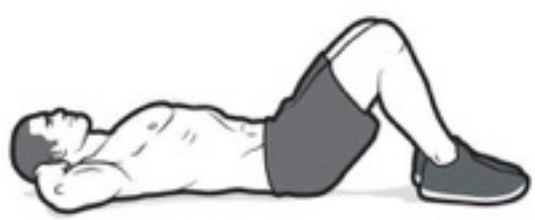


Since a lever varies its resistance between 100% and zero, over the course of 90 degrees, then a 15 degree angle would constitute 16.6% of the distance between horizontal and vertical (15 x 100 divided by 90 =). The 30 degree angle would constitute 33.3%.

Therefore, a 15 degree angle lever would load its operating muscle with 73.4% of the available resistance, and a 30 degree angle lever would load that muscle with 56.7% of the available resistance.

Now, let's apply an actual weight. Let's say we have a lever that weighs 100 pounds at the perpendicular position. That lever would then load its operating muscle with (approximately) 73 pounds when the lever is at the 15 degree angle, and it would load that muscle with (approximately) 56 pounds when that lever is at the 30 degree angle.

In the illustration below, we see a man doing an Abdominal Crunch on the floor (or other horizontal surface, perhaps a massage table). In the starting position (below-left) his torso (i.e., operating lever for the abdominals) is at the 100% position. In the "crunch" position (below-right), his torso is approximately at the 15 degree angle.



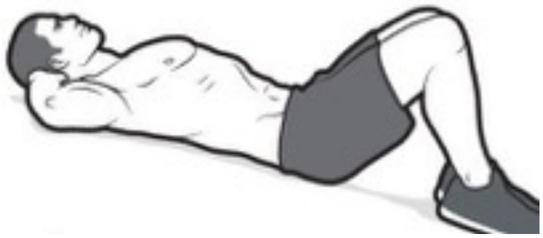
Now, compare these two positions to the circle above. If this man weighs 180 pounds (total body weight), his torso may actually weigh 100 pounds. Therefore, he's beginning this movement with 100 pounds (magnified by the length of his torso, but let's just keep it simple). He's concluding the movement with (approximately) 73 pounds.

Most of us know that this exercise, done this way (on the floor) is fairly difficult. For some people, it's nearly impossible. Of course, this depends on two primary factors - one's torso weight and one's abdominal strength. For the average person, doing this exercise is SO difficult, that it usually prohibits them from doing it correctly.

Ideally, this exercise is should take the abdominal muscle from the elongated position (greatest distance between the origin and insertion of the Rectus Abdominis), to the fully contracted position. But when a person weighs too much, or when their abdominal muscle is anything less than "very strong", they are simply unable to produce a full range of motion. It ends up being mostly head and neck movement, rather than torso.

The simple solution is to lessen the load, by **altering the Resistance Curve**.

Below, we see the exact same movement, performed at a slight incline angle.



Here, I have this person starting at the 15 degree angle, and ending at the 30 degree angle. Therefore, he's beginning the movement with (approx.) 73 pounds and is ending with (approx.) 56 pounds. NOW, this amount of resistance is within his ability to perform the movement properly.

This angle (and various other other angles) can easily be achieved by tilting a massage table, or by using an Incline Bench (and elevating the feet a little bit), or by propping up a simple board against a box or foot stool (at home).

Naturally, the higher the Incline, the greater the reduction of the load. There is no shame in using an Incline angle that is set at 45 degrees, if that provides the "correct" amount of resistance for the individual, at that particular stage of fitness. As he (or she) loses weight, and/or gets stronger, the angle can be lowered. The angle should be selected (adjusted) so that one can do (approximately) 20 repetitions with good form - as shown above - comfortably. Yes, the resistance level should be challenging - but not overwhelming.

Note: The original idea of doing Abdominal Crunches on the floor was based entirely on convenience - not as the "standard test of abdominal strength." There is no logical reason why anyone "should" assume that Abdominal Crunches must be done on a flat (horizontal) surface. Of course, when a person is not overweight, and has sufficient abdominal strength, performing this exercise from a horizontal position is fine. But that should not be the expected norm. Like any exercise, we must SELECT the resistance level that is comfortable and appropriate for us, at that particular stage of our fitness. It should not be the same amount of resistance for everyone.

Ironically, people have tended to make this exercise MORE difficult, rather than LESS difficult. This is absurd. The vast majority of people do not have enough abdominal strength (relative to their torso weight) to perform this exercise properly from a horizontal position. Yet, they still believe it's "better" for them to do this exercise on a DECLINE - making it even MORE difficult.

Note: Making an abdominal exercise "too difficult" to perform properly will compromise development of that muscle, and will also create an injury risk. Further, abdominal exercises do NOT reduce abdominal fat. Abdominal exercises - like exercises for the Biceps or any other muscle - primarily develop the muscle. So the idea of making an Abdominal Crunch as challenging as possible, because the goal is to lose abdominal fat, is misguided.

It is much better to modify the resistance curve of Abdominal Crunches in such a way as to make the movement MORE manageable - decreasing the resistance, if necessary - rather than less manageable. This is just one example of how we can manipulate the resistance curve of an exercise, to make it more productive for us.

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The Ideal Resistance Curve

"Early Phase Loading"

Muscles have an elastic property, such that they typically have more strength potential when they are elongated, and less strength potential when they are contracted. This is known as a muscle's natural "strength curve".

Therefore, it is most sensible to select exercises that provide a "resistance curve" that offers the target muscle more resistance during the early phase of the muscle's range of motion - where the muscle is strongest - and less resistance during the latter part of the range of motion - where the muscle is less strong.

Professor of Kinesiology, Physiology, Neurobiology and Medicine - William Kraemer, Ph.D., along with Steven Fleck, Ph.D., explain muscle's strength curve this way:

"At the optimal length [of the muscle fiber] there is potential for maximal cross-bridge interaction and thus maximal force. With excessive shortening there is an overlap of actin filaments so that the actin filaments interfere with each other's ability to contract the myosin cross-bridges. Less cross-bridge contact with the active sites on the actin results in a smaller potential to develop tension."

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Let's conduct a little experiment. We're going to see what happens when we perform two different Triceps exercises, with completely opposite "resistance curves".

Exercise # 1: Supine Dumbbell Triceps Extension (below-left)
Exercise # 2: Dumbbell Triceps Kickback (below-right)

Let's say you're using a 15 pound dumbbell, with each exercise.

What you'll discover is that although 15 pounds may feel relatively easy during a *Supine Dumbbell Triceps Extensions* (exercise # 1), it feels "awkward" during *Dumbbell Triceps Kickbacks* (exercise #2).

During Exercise # 1, the resistance curve is such that it is **heaviest** when the elbow is bent at 90 degrees (when the forearm is perpendicular with gravity), and **lightest** when the arm is extended straight (when the forearm is parallel with gravity). This **matches** the strength curve of the muscle.

During Exercise # 2, the resistance curve is such that it is **lightest** when the elbow is bent at 90 degrees (when the forearm is parallel with gravity), but that is where we are strongest. Then, the resistance is **heaviest** when the arm is extended straight (the forearm is perpendicular with gravity), but that is where we are weakest.

The resistance curve of Exercise # 2 (Dumbbell Triceps Kickback) is the OPPOSITE of the strength curve of our Triceps muscle. When doing this exercise, we completely miss the opportunity to load the Triceps when it can best handle the load. Then, when we extend the elbow and try to contract the Triceps, it's virtually impossible to straighten the elbow all the way, if we're using the same 15 pound dumbbell we were using with Exercise # 1. It is "too heavy" where we're weakest, when the muscle is fully shortened.

Because of the natural strength curve of most muscles, it is generally more advantageous to select exercises that provide "**Early Phase Loading**" - more resistance in the early part of the muscle's range of motion, and less resistance in the latter part of the range of motion. Let's look at one more example.

“Side Raise” for Lateral Deltoids

When our goal is to work the “Lateral Deltoids”, we usually perform various types of “side raises” (aka “Lateral Raises”). The most common version of this is the “*Standing Dumbbell Side Raise*” (illustrated below). Let’s look at this particular exercise, followed by other versions of a “Side Raise”, and see how the different Resistance Curves compare.

During the “*Standing Side Dumbbell Raise*”, we begin with the arms down at one’s side - parallel with the direction of resistance (“free weight” gravity). Therefore, the Lateral Deltoids are mostly **unchallenged** at this stage because their operating lever (the upper arm / humerus) is in the neutral position, relative to resistance. This is where the Deltoids are **strongest**, yet we provide them with zero resistance at this stage.

Then, as the arms are raised, the operating lever (humerus) encounters into increasing degrees of “perpendicular-ness” with gravity. When the upper arms are parallel with the ground (at the conclusion of the movement, shown in the photo above-right), they are at their “**most active**” (heaviest) position. But this is where the Deltoids are **weakest**.

This is very easy to prove. If you were to use a weight which allowed you to hold the arms parallel to the ground, it would feel extremely light during the earlier stages of the movement. And, if you used a weight that provided a reasonable degree of challenge during the early stages of the movement, it would be impossible to hold that weight at the top.

The resistance curve of a *Standing Side Dumbbell Raise* is the **opposite** of the strength of the Lateral Deltoids. This version of a "Side Raise" fails to provide sufficient resistance at the point where the muscle is strongest (in the early phase of the movement), and then provides too much resistance when the muscle is weakest.

This "backward resistance curve" often encourages people to "swing" the weight up, from the bottom to the top, in order to use a weight that feels challenging. They typically begin with a slight forward bend, and then jerk their torso upward (sometimes even going up onto their tows), in order to REACH the top of the movement. But "swinging" the weight up (using momentum) is not the solution to a backward resistance curve. The solution is changing the the direction of resistance OR changing the position of our body relative to gravity.

The "***Lying** Side Dumbbell Raise"* (shown below) is an example of how we can re-position our body, so that gravity is more perpendicular at the beginning of the movement, and more parallel at the end of the movement.

During this exercise, the humerus begins the range of motion when it is parallel with the ground, which means it is perpendicular with gravity. It's at the 100% position, at the start ("early phase") of the movement, precisely where the Deltoids are strongest.

As the arm continues on it's upward path, the resistance gradually decreases, which is perfect, because the strength potential of the Deltoids is also progressively decreasing. The humerus reaches the conclusion of the movement when it's vertical. At this point, the humerus is parallel with gravity, and therefore neutral. This is fine, because this is the point in the range of motion where the Deltoids are weakest.

Let's look at just one more Resistance Curve example, relative to a "Side Raise" for the Deltoids.

This version - known as a "*Leaning Side Dumbbell Raise*" (pictured below) - has a resistance curve that is LESS favorable than that of the first version.

The starting position (arm hanging straight down) already skips the first 10 degrees of the range of motion. In the original "Standing Side Dumbbell Raise" (shown above) the movement began without any resistance, but at least it began with the arm against the leg (the full range of motion). In this version, the first 10 degrees are skipped entirely.

(Note: One might think the solution here is to simply bring the arm inward, at the beginning, so it starts up against the leg. However, doing so brings the arm to the other side of the "Base", which means it will then begin its movement with a downward swing - requiring NO force from the Deltoid - and then carrying that momentum into part of the range of motion after that. This would make a "bad" exercise, even worse.)

In this version (above), the resistance begins increasing later into the range of motion, thereby exacerbating the flaw of the original Side Raise. Ideally, we want the resistance to start SOONER - not later. We want MORE resistance in the early phase - not LESS resistance in the early phase, and then we want it to diminish as it approaches contraction. We don't want the resistance to increase, as it approaches contraction.

This version is foolish, frankly. There is no logical reason to believe this is an improvement on the original version, which is already flawed. The “Lean” of the torso should be in the opposite direction - away from the range of motion, not toward it - in order to best match the strength curve of the Deltoids.

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Summary

There are a number of physics principles that apply in bio-mechanics, but ultimately they all lead to one overarching factor - **the direction of resistance**.

The “resistance curve” is one of the most important aspects of resistance exercise, and that is directly influenced by the **direction of resistance**.

When we arrive in the final six chapters of this book - the ones that discuss the anatomy - you’ll see that there is another overarching factor - **the ideal anatomical motion** for each muscle and joint.

Exercise assessment and selection is predicated on those two primary themes - the ideal anatomical movement and the ideal direction of resistance.

The **direction of resistance** determines the “**resistance curve**” and “**early phase loading**”. It also determines where the **Apex** and the **Base** are, and it is implicated in a number of other principles which will be explained in the upcoming chapters.

Chapter Five

The Apex & The Base

The "Apex" is defined as the highest point in an arc, or - in the case of resistance training - the point that is farther away from the source of resistance. The "Base" is defined as the lowest point in an arc, or - in the case of resistance training - the point that is closet to the source of resistance.

When a lever moves through an arc, and reaches either the apex or the base, it reaches the neutral position, because the lever is then parallel with the direction of resistance.

Moving the lever (or limb) beyond the apex or the base - to the other side of apex or base - will result in a <u>transition of the load</u> from one working muscle, to a different muscle. In all cases, the load transfers from the muscle that is on one side of the limb or body, to the muscle that is directly on the opposite side of that limb or body.

Crossing over to the other side of the Apex or Base is usually counter-productive, for the purpose of muscular development.

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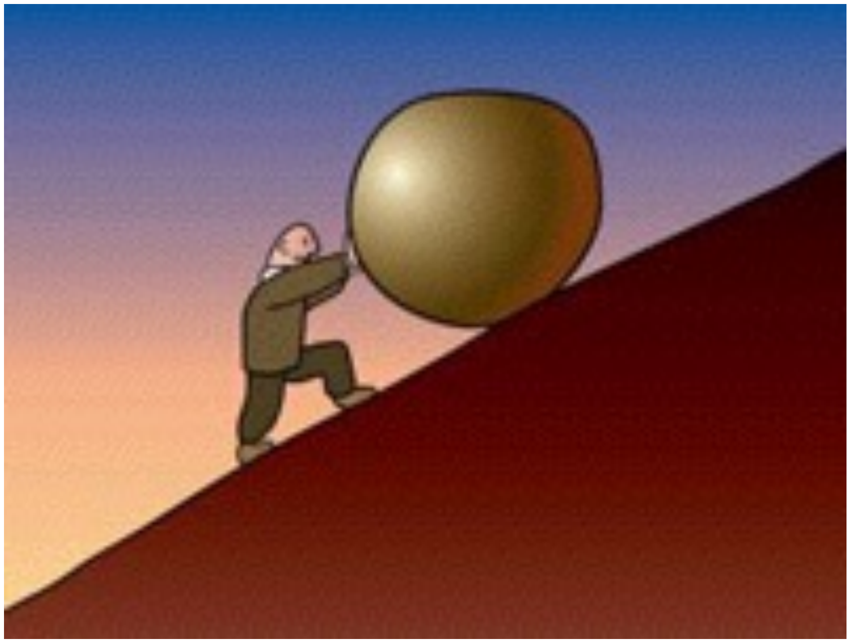
Many of us remember seeing cartoons in our youth, where we see two or three characters ("The Three Stooges", for example), struggling to push a heavy cart up a hill. When they reach the top of the hill, they're able to relax because the cart is at the "Apex" - a neutral position. They would not have been able to take that break when they were pushing the cart up the hill, because it would have rolled back over them if they had stopped their upward push.

While at the "apex" (the neutral spot), the Stooges wipe the sweat from their brows and pat each other on the back. But then one of them accidentally nudges the cart toward other side of the hill, and the cart begins rolling down the other side of the hill, with the Stooges chasing after it.

There is a profound lesson here.



The Stooges' **"north-bound" force** was required on one side of the hill, because the cart was being moved UPWARD, away from downward pull of gravity. However, after it **passed** the Apex (i.e., the neutral point), to the other side, the cart no longer needed any "north-bound" force, in order to continue moving in that direction. It would roll down the hill on its own. In fact, any effort to slow down (or reverse) its north bound free-fall, would require SOUTH-bound force.

This happens in resistance training as well. When the weight is on one side of the Apex (or the Base), it requires force from one particular muscle. But when the weight crosses over to other side of the Apex, it shifts its force requirement to the muscle that is on the **other side** of that lever.

You'll notice that - as we make our way through this book - the various principles we discuss in each chapter begin over-lapping. They are separate principles, but they interconnect. For example, the "resistance curve" relates to the Apex and the Base. As we illustrate the **"transfer of load"** that occurs when a lever crosses over to the other side of an Apex or a Base, we simultaneously illustrate "Opposite Position Loading", "Reciprocal Innervation" and "Range of Motion" (which will be addressed in upcoming chapters), as well as "Mechanical Disadvantage" (which has already been discussed).

“Opposite Position Loading” refers to the fact that the load of a lever always falls on the muscle that is directly opposite the eccentric movement of that lever. “Reciprocal Innervation” refers to the fact that either one muscle OR the opposite muscle, can work at any given time. Two opposing muscles cannot contract simultaneously.

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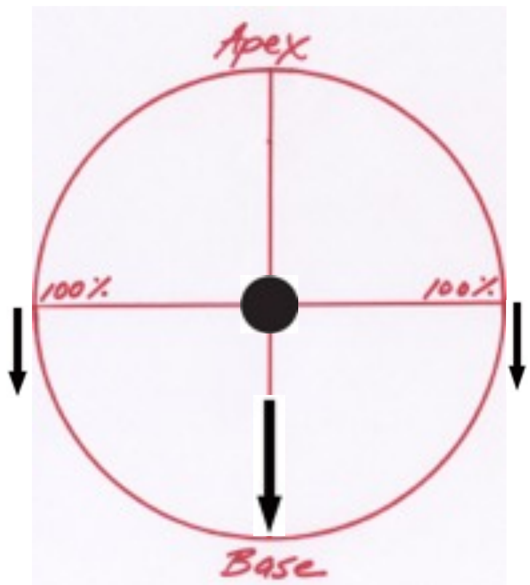
Let’s examine more closely, this “transition of load” that occurs when a lever crosses over to the opposite side of the Apex or the Base.



In the illustration above, we see a circle. In fact, what we are really looking at is a pivot in the center (where the vertical and horizontal lines meet), and **four** different **arcs**. Two of the arcs are the **left** and **right** halves of the sphere. The other two arcs are the **upper** and **lower** halves of the sphere. The **vertical** line indicates the direction of resistance (gravity), coming from the side of the “Base”. The horizontal line represents the point at which a lever is perpendicular with resistance, and thus constitutes the “maximally active” point of the Resistance Curve.

When we lift weights, there is always a pivot - a place around which the anatomical movement rotates. Once the pivot and the direction of the resistance have been identified, we can then establish where the Base and the Apex are, as well as the sequential variations of resistance that will occur when our “limb” (a forearm, for example) travels the course of either the left or right arc. We can also establish to which muscle the load will transfer, if that limb crosses over beyond the Apex or Base.

Let’s now move from the “theoretical” to some “real world” situations.

In the photo above, we see the first part of a demonstration which shows what occurs when a limb is on the upper half of this sphere. The elbow is the pivot, and it is located at the center of the sphere, like the illustration above. The forearm (lever) is on the **upper half** of the sphere, in the Apex position - so it's neutral.

In the photo below, the forearm has tilted to the left side of the sphere. In doing so, it has become an active lever, loading the muscle that is positioned "**opposite** the lean", which is the Biceps. When the lever first departs from the Apex position, it begins with very little resistance. The resistance gradually increases, as the lever enters into a more perpendicular position with gravity. The forearm reaches its "maximally active" position, when it is parallel with the table (i.e., 100% perpendicular with gravity).

Note: Of course, this is not meant to be an actual Biceps exercise. It is only meant to illustrate how the Resistance Curve functions on the upper half of this sphere. However, it also illustrates why a movement like this would NOT be particular good exercise for the Biceps.

Ideally, the Biceps should be able to go through its entire range of motion, with SOME degree of resistance - from full extension to full contraction. However, this particular arc only provides resistance through the first 60% of the Biceps' ROM - thereby leaving the remaining 40% (final part of the range of motion) without any opposing resistance.

In the photo below, the forearm has tilted to the right side of the sphere. In doing so, it has become an active lever, loading the muscle that is now on the other side of the tilt - the Triceps. In other words, the Biceps is no longer "useful" on this side of the Apex, because the weight in the hand will now "fall" farther right - without any "help" from the Biceps. Only the Triceps can slow down, stop, or reverse this downward trajectory, and return the forearm lever back up to the Apex.

This clearly shows how the **resistance transfers** from the Biceps - when the lever is on the left side of the Apex, over to the Triceps - when the lever is on the right side of the Apex.

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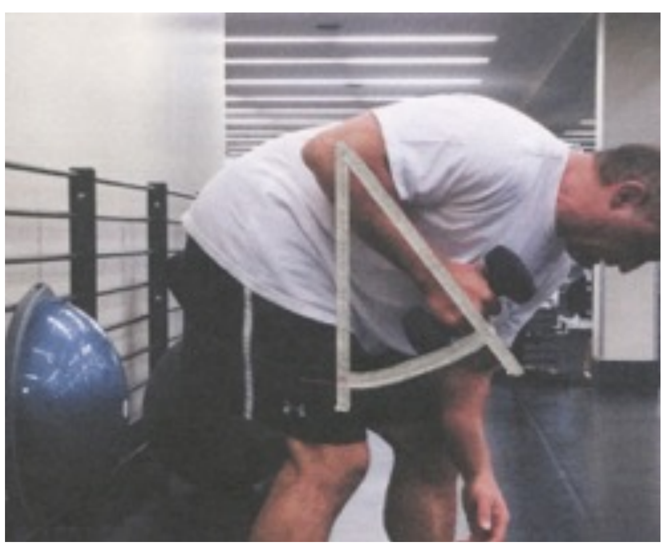
Let us now look at how the Resistance Curve operates on the **lower half** of the sphere.

In the photo below-left, we see the forearm hanging straight down from the elbow. This is similar to the standard "pendulum". The forearm lever is now in the "Base" position. It is neutral.

In the photo above-**right**, the forearm has been tilted to the **left** side of the sphere, thereby loading the **Triceps**. At this point, with the forearm about half way between the Base and the perpendicular position, the Triceps is getting about 50% of the available resistance.

In the photo below, the forearm has been tilted to the **right** side of the sphere, thereby loading the **Biceps** - on the opposite side of the Triceps. Of course, as is often the case when a person performs a *Triceps Kickback*, if the forearm is foolishly allowed to simply DROP from the Triceps extended position (without being controlled by the Triceps), it causes the forearm to swing beyond the Base by sheer momentum. Then, it is again allowed to DROP and swing the other way - foolishly - because it relieves the Triceps of having to do the work.



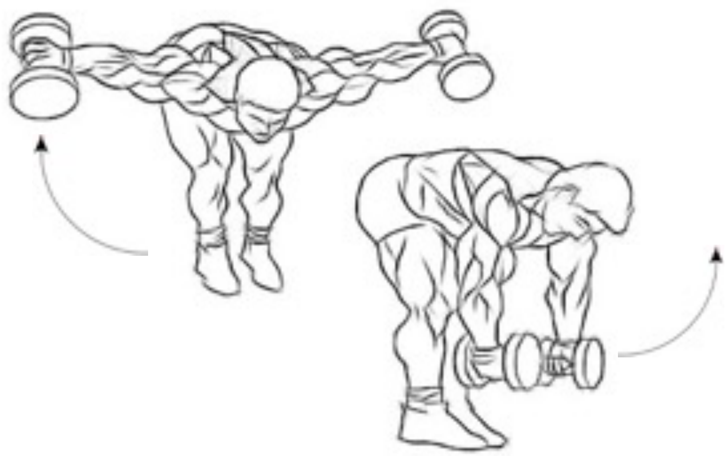
In essence, it becomes like a playground "Swing" - being moved more by momentum, than by deliberate muscular force.

Notice that the tendency to "swing" (allowing the use of momentum) **only** occurs on the bottom half of the sphere - when the lever crosses the Base. It does not happen on the upper half of the sphere - when the lever crosses the Apex.

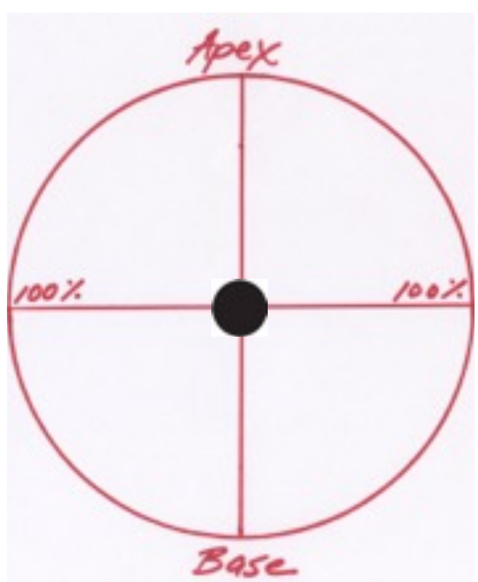
Also notice that - on the lower half of the sphere - the resistance **increases** as a weight is moved upward from the Base to the horizontal line. But - on the upper half of the sphere - the resistance **decreases** when a weight is moved upward from the horizontal line toward the Apex.

In the illustration below (man doing a *Decline Dumbbell Press*), we can see how the upper arm levers are moving through the **upper half of the sphere**. He is starting at the horizontal line and moving toward the Apex. Therefore, the resistance is decreasing as he moves through this range of motion.

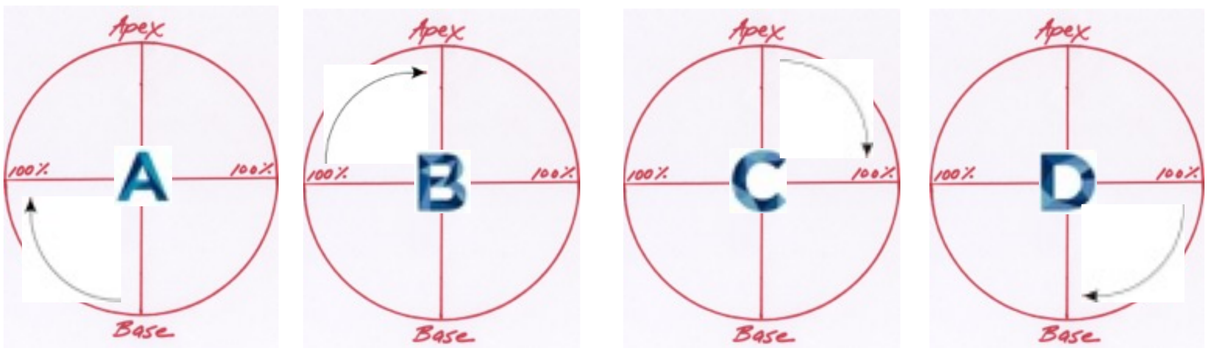
Conversely, in the exercise below (man doing a *Bent Over Rear Dumbbell Raise* for Posterior Deltoids), we can see how the upper arm levers are moving through the **lower half of the sphere**. He is starting at the Base and moving toward the horizontal line. Therefore, the resistance is increasing as he moves through this range of motion.



So, in looking again at the "sphere" which illustrates the Pivot at the center, the left and right arcs, as well as the upper and lower arcs, you'll notice that each "quadrant" is a point of transition.



When a lever (i.e., limb) moves from the Base, up toward the horizontal line on the left, the muscle moving that limb experiences an **increasing** resistance (figure A below). But then, when the lever passes that "quadrant" (the horizontal line), the muscle experiences a **decreasing** resistance, as it moves the limb toward the Apex (figure B below). A transition - from "increasing resistance" to "decreasing resistance" - occurs at that point.



If that lever (limb) continues PAST the Apex (moving clockwise), **another type of transition** occurs (figure C above). The **muscle** which caused the limb to rise up to the Apex, would then NOT be active (nor useful) once the lever passes the Apex. Instead, the **agonist muscle** - the one which controls that lever in the opposite direction - becomes active, and controls the eccentric movement, in this clockwise direction. And that muscle would then be controlling an increasing resistance, until it reached the horizontal line. So, beyond the Apex, there are essentially two transitions - one of muscle and the other of resistance.

When that lever passes the horizontal line on the right side of the sphere, yet **another transition** occurs. The muscle operating the lever on this side of the sphere would then experience a **decreasing** resistance, until it reaches the Base - at which point it's neutral again.

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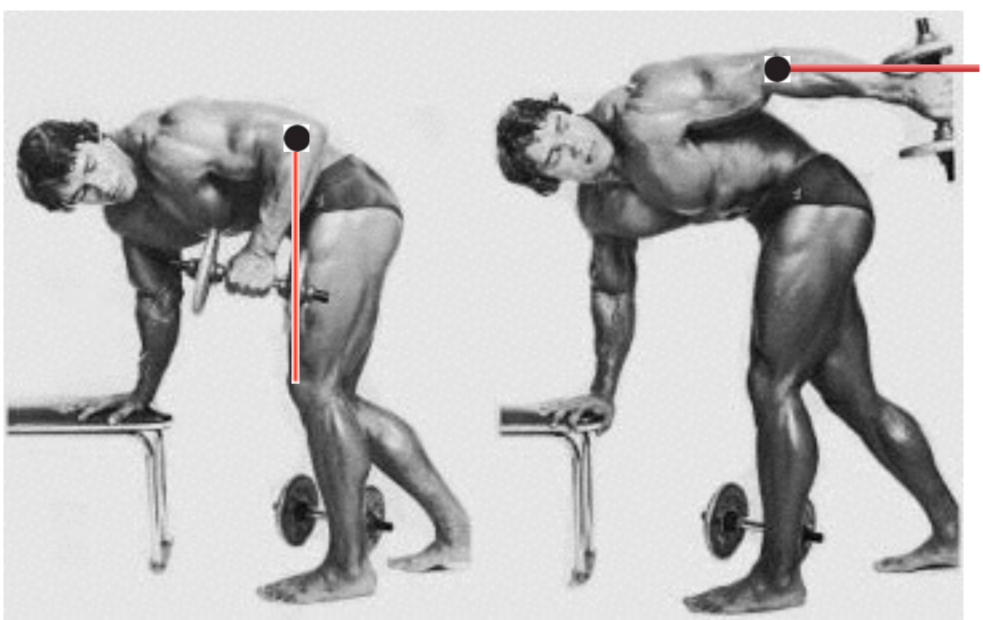
Application

When we work a muscle during an exercise, it is best to use a Resistance Curve that provides resistance for that muscle throughout most (if not all) of its range of motion. Ideally, it would be best to have a Resistance Curve that is "Early Phase Loaded" - providing more load to the target muscle in the beginning - during the first third of half of the range of motion - and then diminishing toward the latter two-thirds or half of the range of motion. This would match the strength curve of the muscle - challenging it when it can best handle it, and easing off when it can least handle it.

Therefore, performing an exercise that causes the operating lever to encounter and pass a Base (or an Apex) in the MIDDLE of the motion, would be very bad. What it means is that the muscle will only have an opposing resistance for HALF its range of motion, and then the load will transition to the muscle that is on the opposite side of that limb, and only provide that muscle resistance for half its range of motion. It also means that the muscle will not be “early phase loaded”; it will probably be “late phase loaded” instead.

Consider the Triceps Kickback, below. Yes - that is Arnold Schwarzenegger in the photo, which illustrates the magnitude of misinformation that has occurred over the last century. Just because Arnold did this exercise, doesn’t make it bio-mechanically “good”. Arnold (and many other successful bodybuilders) typically did / do many exercises for each muscle group, believing they all contribute equally, or contribute something “different” to that muscle. This is not at all correct, and will be further discussed in later chapters.



In the photo above-**left**, I’ve place a vertical red line, starting at his elbow. As you can see, his forearm has already crossed to the left side of the Base - onto the Biceps side of “activation”. While his Biceps is mildly activated, his Triceps “shuts off” completely. This is very foolish, since the exercise is meant to be a Triceps exercise.

His elbow is bent at 90 degrees, which means there is a significant portion of the Triceps range of motion that will not encounter ANY resistance, during this exercise. Most importantly, it’s the “early phase” of the range of motion that won’t encounter any resistance (the first half of the range of motion). The “early phase” is the strongest part of muscle's range of motion, and the part of the range of motion that can most benefit from resistance. And this exercise skips it entirely.

Then, as the elbow is extended, the forearm becomes increasingly "active" - increasing the load on the Triceps. This is also foolish, because the Triceps is losing strength potential at this stage of the range of motion. This is when the Triceps can least handle resistance, let alone in increasing resistance.

After this repetition has reached the "top", and the forearm begins its descent, there is a tendency to allow the weight to just DROP. This would then allow it to SWING past the Base (like the illustration above), which invites the use of momentum to bring it back when the next repetition begins. This is also counter-productive.

This illustrates the problem with allowing an operating lever for a target muscle to encounter / pass either a Base or an Apex in the middle of the range of motion.

Note: There is another problem with this exercise, unrelated to the Apex / Base topic. The Posterior Deltoid is holding the upper arm in place - in that horizontal position. When the elbow is bent, the Posterior Deltoid is loaded with an amount of weight that is produced by the weight held in the hand, plus the magnification produced by the length of the upper arm (even though the Triceps is not loaded at all, at this point). When the arm is straightened, the Posterior Deltoid is loaded with an amount of weight that is produced by that same weight, but twice the lever length. In other words, the Posterior Deltoid gets more load during a Triceps Kickback, than the Triceps does. Yet, since the Posterior Deltoid is only "holding" tension (isometrically), it's not benefitting from the work. This exercise is truly a waste of energy - a very high "investment" of effort with very little reward.

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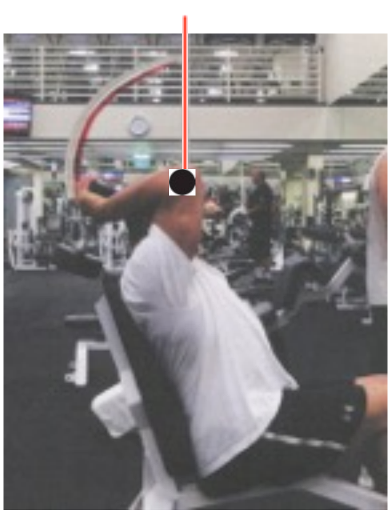
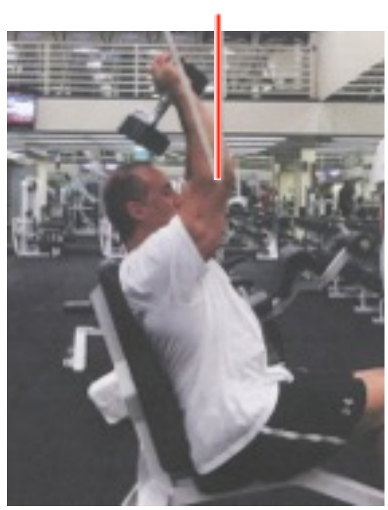
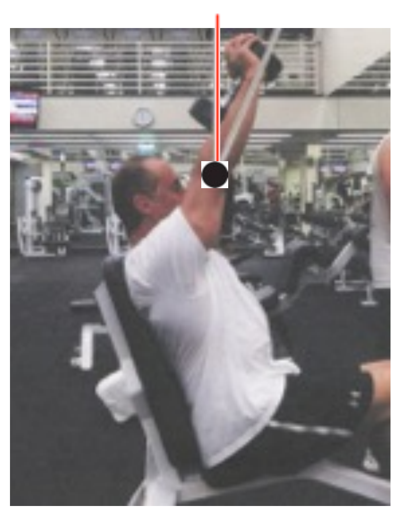
Another Example

In the photos above, I demonstrate what happens when the forearm crosses over to the other side of the Apex. While doing the Overhead Triceps Extension, the Triceps are loaded - as long as my forearms stay on the left side of the Apex. When my forearms reach the Apex, my Triceps are no longer loaded because the operating lever has reached the "parallel with gravity" position - yet my Triceps have not completed their range of motion. Then, by crossing the Apex (in an effort to complete the range of motion), I've transitioned the load to the muscles that are on the opposite side of the arm - the Biceps and the Deltoids.

The problem here begins with the fact that the upper arms are not vertical. Naturally, when the elbow is fully extended, the forearms will be in line with the upper arms. So, if the upper arms are slanting forward (as they are here), so will the forearms when the elbows are fully extended. Yet, trying to position the upper arms vertically - while sitting at this angle - would be very uncomfortable for the shoulder joint. The only solution here would be to allow the torso to be more reclined. This would allow the shoulders to be in a comfortable position, and yet still allow the upper arms to be more vertical. This would then allow the forearms to stay on the left side of the Apex, when the elbows are fully straight.

Note: This exercise - the "Overhead Triceps Extension" - is not more beneficial than are Triceps exercises that do not require the arms to be overhead. So the question of how to perform this exercise without having the forearms cross the Apex, and still have the humerus in a comfortable position, is academic. This will be further explained later.

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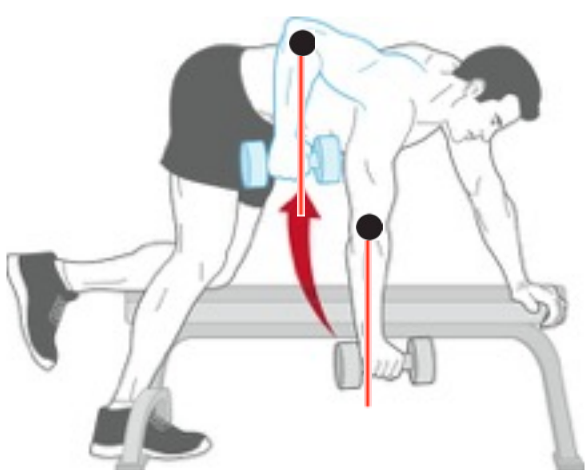
How the Apex and / or Base Interacts with a Secondary Lever

In the illustration below, we see a man performing a *One Arm Dumbbell Rowing* exercise. In this particular exercise, his forearm is the secondary lever to his humerus. The humerus is the primary lever for the Lats.



However, the forearm must participate because the weight is held in the hand - and cannot be directly connected to the humerus. Therefore, the forearm is the secondary lever in this exercise. It essentially acts as a “connector” between the weight and the humerus.

In the photo above, I’ve place a red vertical line, starting at the elbow, to highlight where the forearm is, relative to the Base position. The Base is neutral, and - ideally - we’d like the forearm to be neutral during this exercise, while the upper arm bone (the humerus) plays the role of “active” lever. Both, in the “down" position and the “up” position, the forearm SHOULD be neutral - perfectly vertical.

Since we usually cannot SEE our forearm while we’re doing *One Arm Dumbbell Rowing*, we may not be aware of whether or not it’s perfectly vertical throughout the range of motion. People sometimes have a tendency to tilt the forearm back (toward the butt) or forward (toward the head) when pulling the humerus upward. When this happens, it causes either the Triceps or the Biceps to become unnecessarily “active”. This results in wasted energy, or even fatigue in the Triceps or Biceps, to the point of causing the set to end prematurely.

Knowing that crossing to the other side of the Base transfers the load to the muscle of the opposite side, allows us to make this adjustment during any exercise. In other words, if we “feel” fatigue in the Triceps while doing this exercise, we know we’re tilting the forearm posteriorly. We can then intentionally tilt the forearm anteriorly (toward the front / head), because doing so will mildly activate the Biceps - and shut OFF the Triceps.

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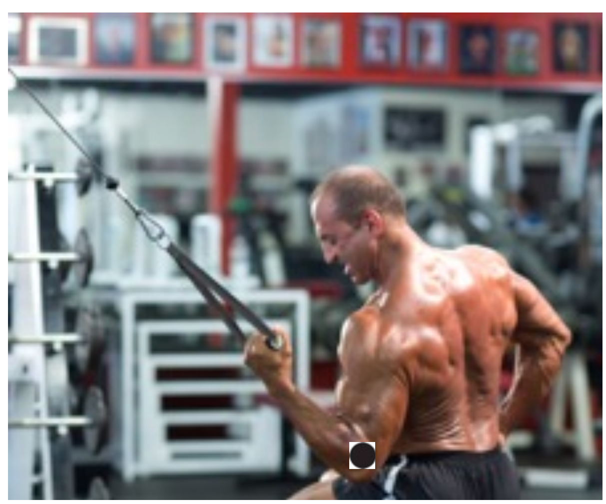
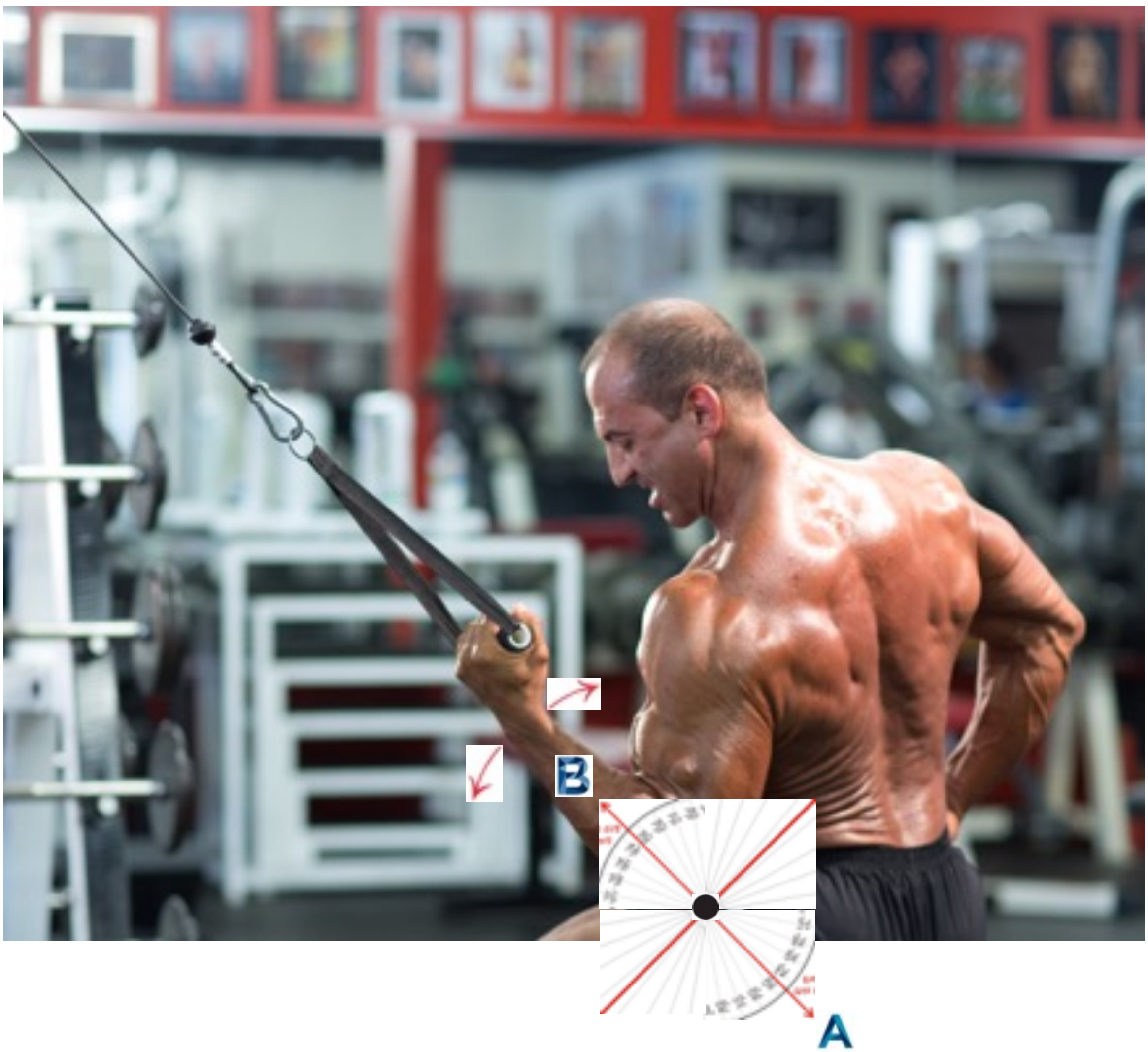
The same is true during this exercise (below) - the *One Arm Lat Pull-In*.



If we feel fatigue in either the Biceps or the Triceps, while doing an exercise that is intended for the Lats, we know that we are failing to keep that lever (the forearm) perfectly “neutral” - parallel with the direction of resistance. **However**, in THIS case, the direction of resistance is the cable, not “free weight” gravity.

So, in a case like this (where the direction of resistance is a cable), the BASE is whatever is parallel with the cable, **and closest to the pulley** (“B” below). The Apex is directly opposite the Base - parallel with the cable, but farthest from the pulley (“A” below). The elbow is the pivot. And the “horizontal lines” are whatever angle is perpendicular with the cable, on either side of it. All the same rules of “transition of load” still apply, but from this different angle.



If we feel fatigue in our Biceps, when we perform this exercise above, we need only tilt our forearm (slightly) to the other side of the Base, and mildly activate the Triceps - in order to completely shut off the activation (and fatigue) of the Biceps - and vice versa.

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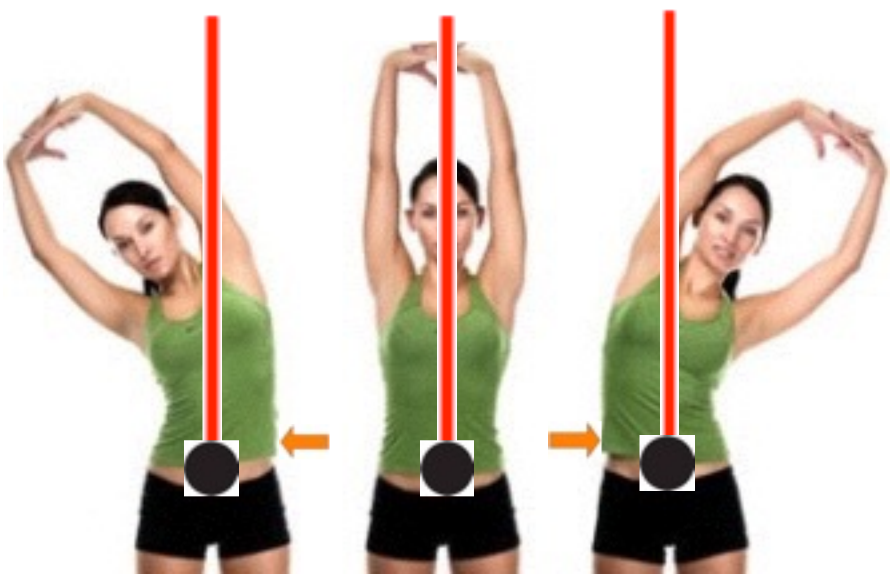
Summary

In the previous chapter, we learned that the Base and the Apex are part of the Resistance Curve.

In this chapter, we learned that when a loaded lever crosses over to the other side of the Apex or Base, it results in a **"transition of load" .** This **always** shifts the load directly to the muscle that is on opposite side of the lever.



In the photos above, we see a woman in three positions. In the center photo, her torso-lever is at the Apex - balanced directly over the pivot. Her torso is the operating "lever" of her Obliques - in this scenario. In this position, her torso lever is neutral, and therefore her Oblique muscles are not loaded.

When she tilts her torso lever to **her** right side (photo on the left), the weight of her torso loads the Oblique muscles (External and Internal Obliques) that are on the LEFT side of her torso. As we'll learn in Chapter 8, whichever muscle is positioned directly opposite resistance, will be most loaded. In this case, her left Obliques are positioned on the opposite side of her right-leaning torso tilt.

When she tilts her torso to **her** left side (photo on the right), the weight of her torso loads the Oblique muscles that are on the RIGHT side of her torso. Both sides (right

Obliques and Left Obliques) cannot be loaded at the same time, because each is the "agonist / antagonist" of the other. We'll learn more about this concept in Chapter 11.

This transition of load is typical of what happens whenever a loaded lever (i.e., limb) crosses the Apex or the Base, during an exercise. In circumstances when this happens, the questions we should ask ourselves are the following:

1. **Am I aware that I am crossing the Apex (or Base) right now, and that the load has shifted to a different muscle?**

2. **Is that transition of load <u>compromising</u> the benefit of this exercise?**

3. **If so, is there a better way of achieving my objective?**

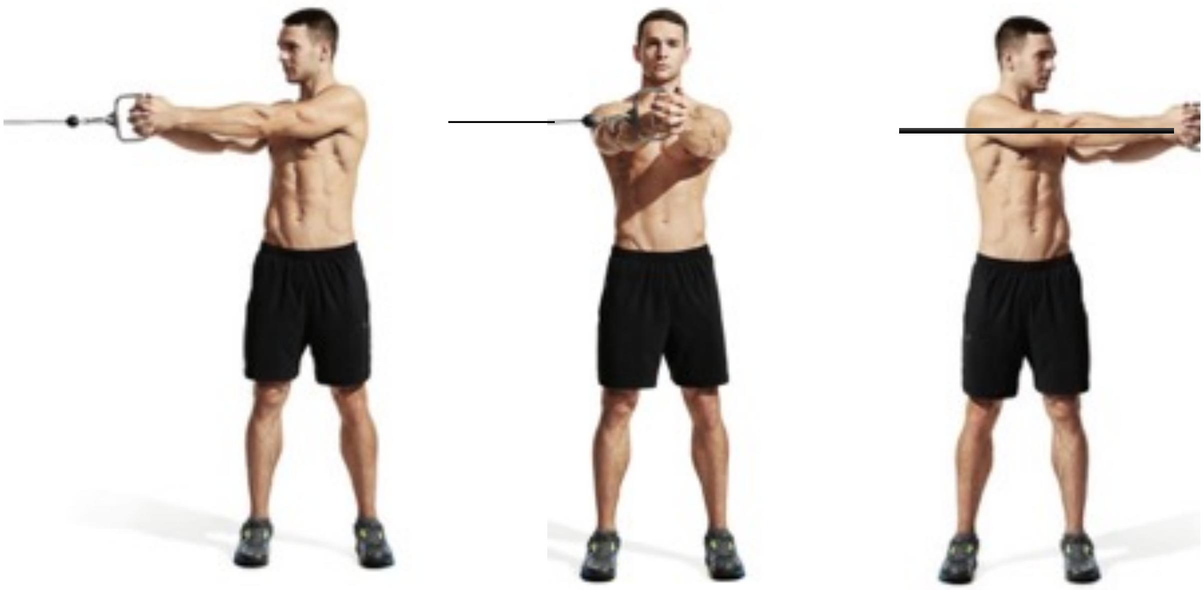
4. **Or, is that transition of load working in my <u>favor</u>, at this moment?**

The exercise above (**Bodyweight** Side-bends), is not "great" - unless one's objective is simply stretching and moderate activity. If the objective is to really "work" (develop) the Oblique muscles, this version of *Side Bends* is not very productive.

In the scenario above, each side (Oblique muscles) is only getting resistance through HALF its range of motion. Specifically, it's only getting resistance on the "stretch" half - not on the contraction half.

The photo below shows the solution to this. By adding One-Sided resistance, we essentially create an entirely new Resistance Curve. No longer is the vertical torso position "neutral", because the downward force of gravity is NOT the only (nor the primary) resistance source - when we use a side pulling cable, as below. In the photos below, I am using a left pulling resistance, to load my right Oblique muscles.

A similar situation occurs when we do *Torso Rotation with a Cable* - shown below*.*



In the above scenario, the action is a right-moving Torso Rotation, against a **left-pulling resistance**. The Range of Motion is the entire movement you see above - from a fully rotated torso angling left, to a fully rotated torso angling right. The photo in the middle (above) is the **mid-way point** of the movement, and the point at which the greatest resistance will occur - in this scenario. That is the point where the our lever (our extended arms, acting as the secondary lever of the torso) meet resistance perpendicularly.

However, if the resistance were pulling straight forward, on the middle photo above, that would be the neutral / Base position - instead of the "maximum" position. Rotating to the left or to the right, from center, would only provide resistance for HALF the range of motion, in each direction.

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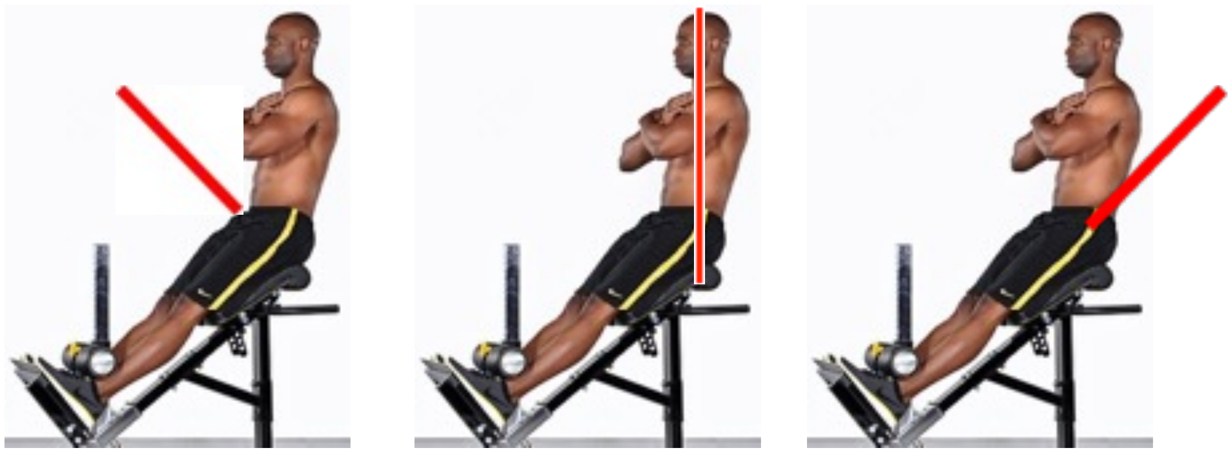
If we were seated on a bench (photo below), with our torso perfectly upright, we would have our torso positioned at the Apex. There, it is neutral - balanced over our pivot (which is our pelvis). If we tilt our torso to the posterior (back) side of the Apex, we load our abdominal muscles. If we tilt our torso to the anterior (font) side of the Apex, we load our Erector Spinae ("lower back" muscles).



The Apex and the Base are neutral positions, but they are also the point at which the load transitions from the muscle that is on one side of the “limb”, over to the opposing muscle, on the opposite side of the limb.

Chapter Six

Primary & Secondary Resistance Sources

When we do “Resistance Exercise”, we typically use several forms of resistance - free weights, cables / pulleys, machines, bodyweight, etc. - in order to challenge our muscles. Often, we combine resistance sources in a single exercise.

When we perform Barbell Squats, the “primary resistance” we’re using is our own bodyweight. We then add a “secondary resistance” source (e.g., a barbell) which combines with our bodyweight, in providing downward resistance, against which our muscles (Quadriceps, Glutes, Erector Spinae, etc.) must work.

In cases like that of Barbell Squats, the “primary resistance” and the “secondary resistance” are <u>both</u> bearing straight downward. Other times, however, the two resistances are bearing in <u>different</u> directions.

Understanding how these two (and sometimes three) sources of resistance combine and produce a result that is different from the use of only one source, is part of understanding Bio-Mechanics.

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When we do “Bodyweight” exercises - Free Hand Squats, Chin-Ups, Parallel Bar Dips, Push-Ups, Ab Crunches, etc. - it’s clear that the source of resistance is our own bodyweight. Sometimes we add a “secondary resistance” source, by putting a barbell on our shoulders, a chain with a weight around our waist, or holding a pair of dumbbells. In cases like these, we have two sources of resistance - both of which may **seem** to be acting as one. Yes, both DIRECTIONS of resistance are the same - i.e., straight down -

but the **placement** (position) of the secondary resistance influences the mechanics of the exercise.

For example, in the photo **above-right**, the man is holding a pair of dumbbells in his hands. But, since the hands are attached the arms, and the arms are attached to the highest part of the torso, the weight of the dumbbells makes the torso more “active” (as a weighted lever) than if no added weight were held in the hands. The heavier the weight held in the hands, the more this matters.

As we learned in Chapter One (“Primary and Secondary Levers”), holding the dumbbells farther out in front of us would essentially “lengthen” the torso (as a lever), while holding the dumbbells farther back would essentially “shorten” the torso (as a lever). This would have the effect of loading the lower back MORE (in the first scenario) or LESS (in the second scenario).

However, holding a barbell on one's shoulders makes it impossible to shift the weight forward or backward. The weight of the barbell is typically placed at the highest end of the torso, thereby magnifying the load on the lower back much more. Furthermore, adding a barbell (or dumbbells) to the Squat adds a downward compressive force on the spine. Again, the heavier the weight used, the more this matters. Adding weight onto the shoulders doesn't only effect the Quadriceps and Glutes.

So, a secondary resistance DOES influence the mechanics of an exercise, due to the **placement** of that resistance - EVEN if the direction of the secondary resistance is the **same** as that of the primary resistance.

Secondary Resistance Pulling from a Different Direction

Sometimes we use resistance from a cable as our primary source, and the secondary resistance is pulling from a direction that is **opposite** than the primary resistance.

For example, when we do a *Lat Pulldown*, the direction of the "primary resistance" is upward - toward the pulley. But there is a secondary resistance source, and it has a **different** direction of resistance, though most people are not aware of it. While the cable is pulling our arms upward, the weight of the Lat Pulldown bar, as well as the weight of our arms, is being pulled downward. In essence, the amount of the bar and of our arms is "assisting" our downward effort. In fact, it is subtracting from the upward pull provided by the cable.

Let's say we're using 100 pounds on the Lat Pulldown machine. The Lat Pulldown bar weighs 20 pounds, and the weight of our arms could be another 20 pounds (average 10 pounds per arm - the average human arm is 5.3% of a person's total bodyweight). So that's 40 pounds that is be subtracted from the weight we're using on the machine. In essence, the weight with which the Lats (and other assisting muscles) are loaded may only be 60 pounds (not including the magnification of arm length, etc.).

Let’s look at some other examples where the primary and secondary resistance sources are pulling in directly opposite directions. Then we’ll look at examples when they’re pulling in directions that are different from each other, but **not directly opposite** each other.

When we do Triceps Pushdowns with a cable, we are pushing downward - against an upward resistance. However, simultaneously, the weight of the Pushdown handle (bar) and also that of our forearms, are being pulled downward. This **subtracts** from the load used on the pulley (…*imagine if the “pushdown bar” weighed 20 pounds - how that would subtract from the upward pull of the cable*). But when we do Standing Cable Curls, the weight of the bar and that of our forearms ADDS to the downward resistance of the cable.

Of course, this is true for many exercises in which we are either pulling upward or downward. For example, Leg Extensions and Seated Leg Curls create a similar situation. With Leg Extensions, the weight of the machine’s lever arm, plus the weight of our lower leg, are **added** to the resistance we’ve selected on the machine - because we are moving all of it upward. However, with Seated Leg Curls, the machine’s lever arm and the weight of our lower leg are subtracted from the weight we’ve selected on the machine - because the machine’s resistance is pulling upward, but the weight of the lever arm, and that of our lower legs, is being pulled downward.

In situations like the ones above, the secondary resistance source either “adds to” or “subtracts from” the primary resistance source, but the mechanics of the exercise are not altered much, if at all, by the secondary resistance source.

 

However, sometimes the direction of the primary resistance and of the secondary resistance are SO different from each other (not on the same plane), that they **do** alter the mechanics of an exercise.

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In the exercise below - *Cable Squats* - we have two different resistance sources. Interestingly, it's somewhat difficult to know which to call the "primary" or the "secondary" resistance source - in a case like this.

We could consider this a "Bodyweight Squat, with added Cable Resistance" - in which case "bodyweight" would be the primary resistance, and the "cable resistance" would be the secondary resistance source. However, once a person begins using more weight on the cable resistance, than their own bodyweight is providing, it seems we should consider the "cable resistance" the primary source. But this would just be semantics.

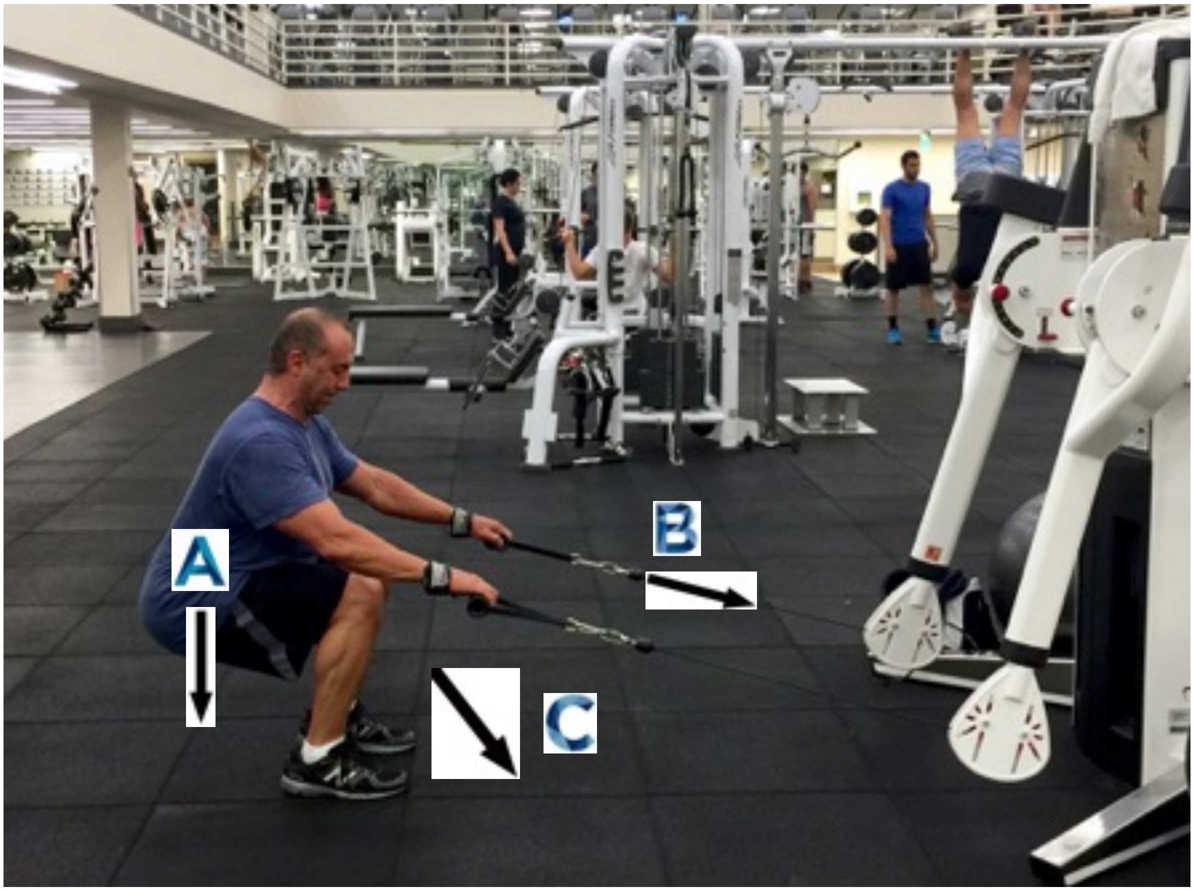
What we know is that both “sources” are contributing resistance, and each has a different direction of pull.

A. “Straight Down” is the direction of resistance that is being applied by “gravity”, on bodyweight.

B. The direction of the Cable pull is between 40 degrees and 20 degrees - depending on where my body is positioned during the range of motion. For the sake of analysis and explanation, let’s just average it at 30 degrees.

My bodyweight is about 200 pounds. So, if I were to use 200 pounds with the pulleys / cables, the two directions of resistance would meld into one “composite” direction of resistance somewhere around 60 degrees. This would be the average between 90 degrees and 30 degrees. The less used on the cables, the closer that composite direction moves toward 90 degrees. The more used on the cables, the closer that composite moves toward 30 degrees.

The goal, with this exercise, is provide a more perpendicular direction of resistance - relative to the Tibia (the operating lever of the Quadriceps). Therefore, ANY amount of forward pulling resistance would move the “composite” direction forward from the 90 degree direction - and that would be good. Of course, this also requires some degree of balance. So, while we could move the pulleys up, and provide a more drastic forward pull, it would be difficult to prevent having the cables pull us off balance. Some degree of downward cable pull is therefore required, in order to lessen our need to lean back so far.



The point is that these two directions of resistance (“A” and “B”, above) BLEND together, and create a new direction of resistance that is neither 90 degrees (“straight down” gravity) nor 30 degrees (the average angle of the cables). Of course, this composite direction of resistance is invisible - as is gravity. Only the direction of resistance provided by the cable, is visible.

Assessment of an exercise like this - specifically, where the Tibia becomes perpendicular with the direction of resistance - requires an understanding that this exercise has **two resistance sources**, and that they produce a **composite** direction of resistance somewhere in between. The composite direction of resistance (“C”, above) has to be surmised, based on knowing the other two factors.

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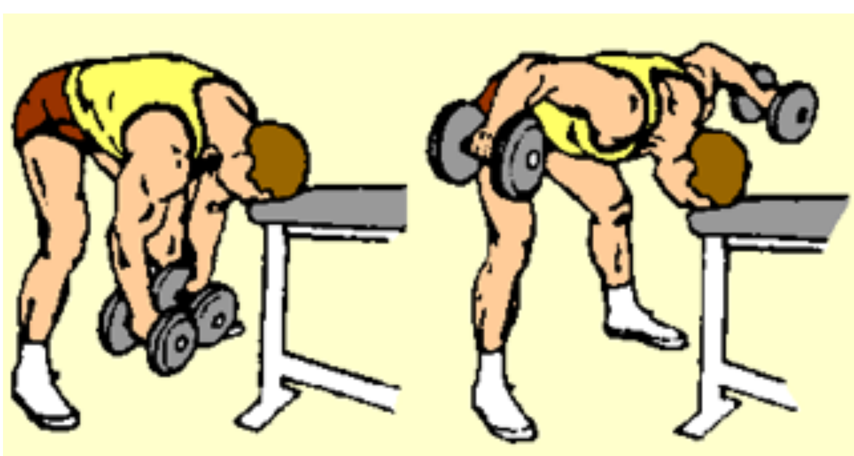
Let’s look at an example which shows how we can strategically **separate** the primary and secondary resistance directions, so that we are able to target the muscle of our choosing, and simultaneously eliminate the unnecessary strain, discomfort and injury risk which would otherwise be directed at a non-target area. But first, let's look at the typical "problem".

When we do ***Bent Over Rear Deltoid Raises*** with dumbbells (shown below), our goal is to target the Posterior Deltoids. In this case, the **primary resistance** is the dumbbells - which is only intended for the Posterior Deltoids. However, the lower back is being loaded with the weight of the dumbbells (primary resistance) AND the weight of bent-over torso (**secondary resistance**). In essence, the lower back is working harder than are the Posterior Deltoids, because it's getting more load. The secondary resistance is not contributing anything to the Posterior Deltoids.

Below is one possible solution this problem. It's the same exercise - as far as the Posterior Deltoids are concerned - but using a bench to support the weight of the torso (via the head). In this case (below), the secondary resistance has not been entirely eliminated, but has been diminished considerably.



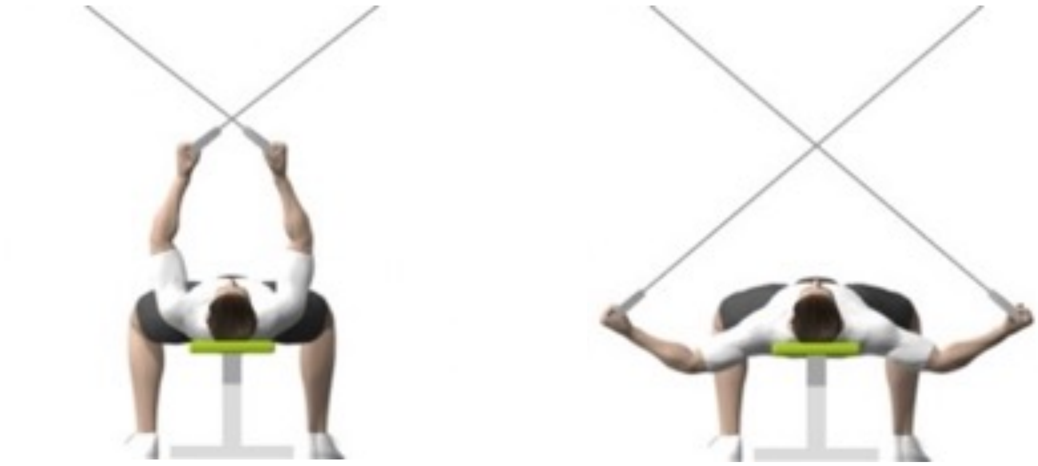
Yes, this is a better option - but it still has a problem. Both of these versions are not "Early Phase Loaded". The resistance is "lightest", in the beginning of the range of motion - where the Posterior Deltoid is strongest. Then, the resistance is "heaviest", at the end of the range of motion - where the Posterior Deltoid is weakest.

Below, we see a third version, performed with cables. The primary resistance source is the cables, and - as you can see - they are coming from two different directions. It might appear as though we have TWO primary resistance sources - one for each Posterior Deltoid (left and right). But each Posterior Deltoid only one ONE primary resistance source.

We also have a certain amount of downward pull on the torso, which is **separate** from the resistance being applied to the Posterior Deltoids. This downward resistance is a combination of the torso weight, and the COMPOSITE direction of resistance produced by the two separate cables.

Because the cables are not pulling straight down, as were the dumbbells in the first example above, there is LESS downward pull coming from them - as compared with the straight down pull of the dumbbells. Based on the angle of the cables (approximately 30 degrees), it appears as though the composite downward pull of the cables is approximately half as much as "free weight" dumbbells would produce. So, this would cause a little bit less strain on the lower back than would using dumbbells, and the Posterior Deltoids are worked better - due to the "early phase loading" the cables are providing.

Below is the same movement and Resistance Curve as the previous version, but this one is performed while lying supine (facing upward) on a flat bench.



In this version, the **primary resistance** is the weight attached to the cables, and our torso weight has essentially been eliminated. It is no longer a factor in this version. Our lower back is not at risk, and we are in a comfortable position from which we can focus on targeting the Posterior Deltoids.

There is a new **secondary resistance** source here, however - the weight of the arms (and handles, although they don't weigh much). They are being pulled downward by gravity, while the cable resistance is pulling them upward. Therefore, the amount of weight used on the cables must be increased slightly to compensate for the weight of the arms. But that's inconsequential. This exercise provides a productive Resistance Curve for the Posterior Deltoids, without the problems associated with our torso weight overloading our lower back.

This is not to suggest that the above exercise is "the best" Posterior Deltoid exercise, but the four exercises above demonstrate that there is often a secondary resistance source during exercise. Sometimes it works against us, and sometimes it works in our favor. But unless we are aware of it, we are not in control of it. It is in control of us.

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<u>Improperl</u>y Adding a Secondary Resistance Source

In the illustration below, we see a man performing this exercise correctly. He is holding a dumbbell in his right hand **only**. He is **not** holding a dumbbell in his left hand. There is a VERY good reason why he is **not** holding a dumbbell in his left hand.

Holding only ONE dumbbell in the right hand causes the torso to be weighted only TOWARD the **right** side. This forces the LEFT "Obliques" (muscles on the side of the waist) to contract in opposition of the pull toward the RIGHT.

This exercise must be performed in **two** stages, because each side pulls in OPPOSITE directions. The left Oblique muscles are challenged (“worked”) by a weight that is held in the right hand - which is pulling the torso to the right. The right Oblique muscles are challenged by the weight that is held in the left hand - which pulls the torso to the left.

Despite the obvious logic of this, we occasionally we see people in the gym performing this exercise while holding a TWO dumbbells - one in each hand (below). In other words, a secondary resistance source has been added - but instead of improving the exercise, it significantly compromises it.

This simply creates an effect similar to that of a “see-saw” - shown below. The two sides balance each other out, so that no actual force is required by the Oblique muscles of either side. However, the downward pull of the two dumbbells does load the Trapezius unnecessarily. It also produces downward compression on the spine. So, while little or no benefit is being bestowed on the target muscle (the Obliques), the body is still being strained - unproductively.

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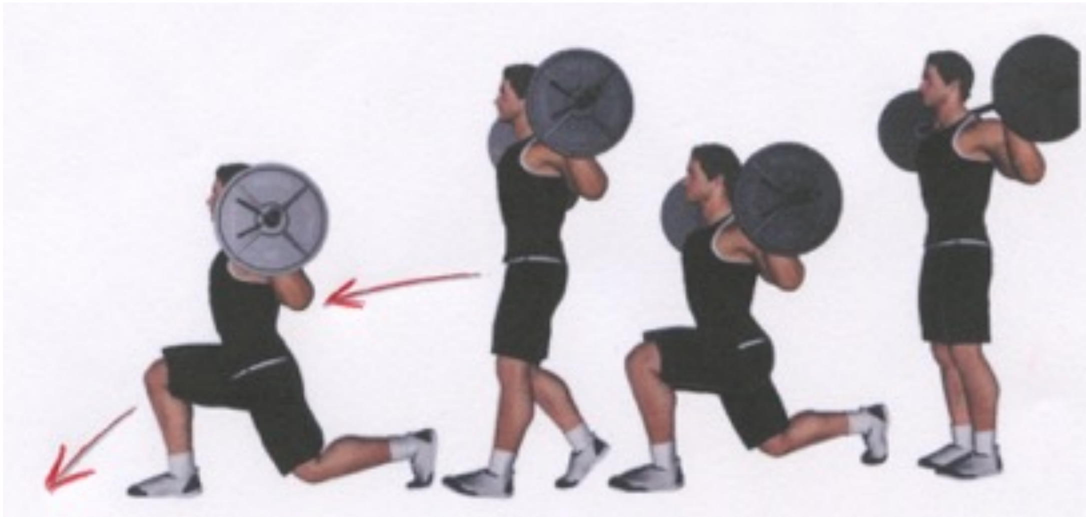
A Third Resistance Source

In addition to the two resistance sources discussed above, there is also - sometimes - "**centrifugal force**". This form of "resistance" comes from movement, "wanting" to continue along the path it has been launched. You might recall Sir Isaac Newton's First Law of Motion, part of which states that "***An object in motion continues in motion… unless acted upon by a {opposite} force***."

An easy example of this would be if you were lying on your back, on a bench, "pressing" a pair of 20 pound dumbbells. Because you have much more strength than would be challenged by such light weights, you push them up VERY fast. In essence, you'd be launching them. You could let them go, and they would continue their upward trajectory, without needing any additional effort on your part - until gravity soon brings them back down. Centrifugal force is also known by another name - "momentum".

If we were to perform "Walking Lunges" while holding a barbell across our upper back (shown above), we are using THREE sources of resistance. These would include our bodyweight, plus the barbell on our back, plus the forward momentum created by walking.

In a situation like this, our bodyweight plus the barbell on our back COMBINE with the forward movement, and produce a **composite** direction of resistance. The assessment of the exercise below, therefore, would need to consider the downward-forward slanting direction of this **composite**. Specifically, we would need to examine how that composite direction of resistance interacts with the various levers in play - perhaps most importantly, the Tibia and the Femur.

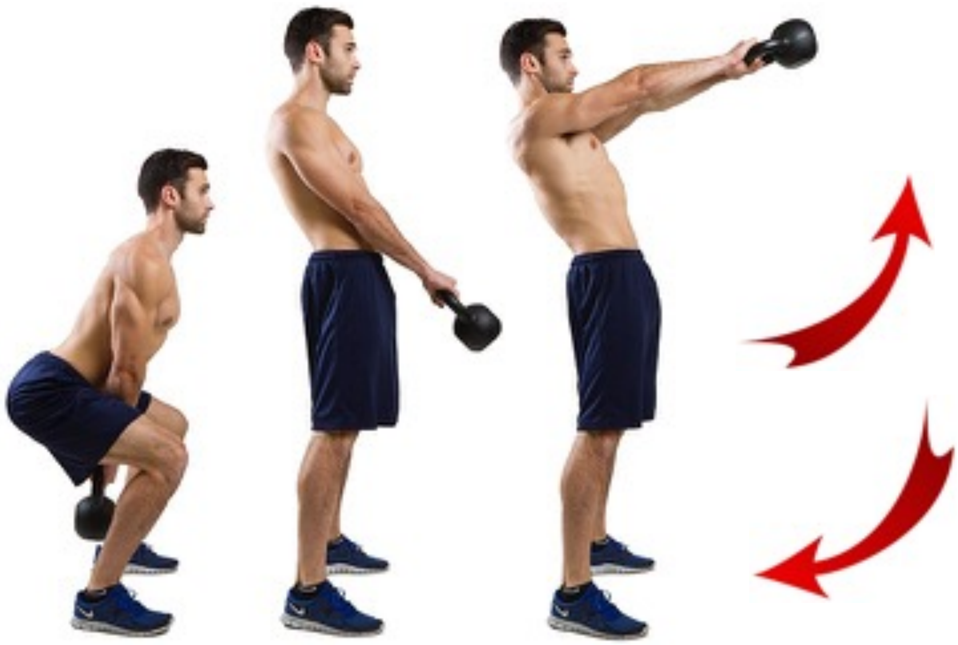


The red arrow (above) estimates the trajectory of the composite direction of resistance. As you can see, that direction of more perpendicular with the tibia, as compared with the straight downward direction of resistance provided by regular squats. However, this illustration above shows the eccentric phase of the movement. The concentric phase - pushing back upward would require another set of photos, as the body position would change.

Nevertheless, the point is that one might assume there is ONLY a straight downward direction of resistance, provided by the bodyweight and the barbell - the primary and secondary resistance sources. However, the addition of a forward movement (on a different plane than simply up and down), creates an entirely different direction of resistance than would otherwise be expected.

This is certainly true of many Kettle Bell exercises, because they often involve some degree of swinging. In fact, this is an integral part of the strategy behind the use of Kettle Bell - at least in regard to these types of exercise.

In order to assess an exercise like the one below, we would need to consider the weight of the Kettle Bell, the speed of the swing, the trajectory of the centrifugal force, and the position of the limbs through that trajectory - in order to understand which muscles are loaded, how much they may be loaded, and at which time (through the swing) they would be loaded. But, as you can see, the direction of resistance is not linear - straight up and down. It is curved, like that of the Walking Lunge above - but more so.



Fortunately, most of the exercises performed in Physique Development programs are linear, or otherwise without “swinging”. Therefore, there is very little centrifugal force occurring in most “physique development” exercises. Or, I should say, there is very little “intentional” centrifugal force. If it is done, it is done without knowing that it has been brought into the equation. In most cases, it significantly detracts from the value of an exercise, which is why it is often called “cheating”.

As we’ll learn more fully in Chapter Fifteen (“Momentum”), allowing centrifugal force to play much of a role in Physique Development exercises, usually compromises the potential benefit of the exercise, and often increases the risk of injury.

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Summary

In situations (exercises) involving ONLY body weight as resistance, there is only a "primary" resistance source. That resistance follows all the bio-mechanical principles discussed in this book.

When a "secondary" resistance source is employed (i.e., dumbbells, cables, elastic bands, machines, etc.), we need to consider its direction of resistance, and how that interplays with the direction of the primary resistance.

In most cases, the secondary resistance will have some effect on the primary resistance. It will either reduce it, negate it or add to it, and it may also activate other non-target muscles in ways which are not productive. It may even increase the risk of injury.

Whether we refer to **body weight** as the "primary" resistance source, and the **added resistance** (barbell, dumbbells, cables, elastic bands, etc.) as the "secondary" resistance source, is irrelevant.

What matters most is that we understand that there is more than one resistance source in most exercises involving barbells, dumbbells, cables, machines, etc. The weight of our body, our limbs, and that of any handles, will always be pulled downward by gravity, regardless of the pull in any other direction provided by another source.

Chapter Seven

Alignment

"Alignment" - in the context of Resistance Exercise - refers to the direction of movement, the direction of resistance, the trajectory of the operating lever of the target muscle, the origin and the insertion of the target muscle, all being on the same plain.

When this occurs, a certain "efficiency" is achieved, such that most or all of the "load" (resistance) is directed toward the target muscle. When these markers are NOT in alignment, a percentage of the load is diverted away from the target muscle, thereby diminishing benefit, and joint rotation / stress occurs.

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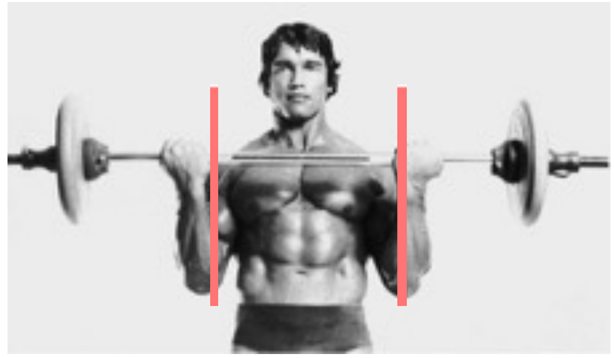
When we see someone doing a ***Standing Barbell Curl*** (for their Biceps), we take for granted that as the person pulls **upward**, gravity is pulling directly in the opposite direction (i.e., **downward**), along the same plane.

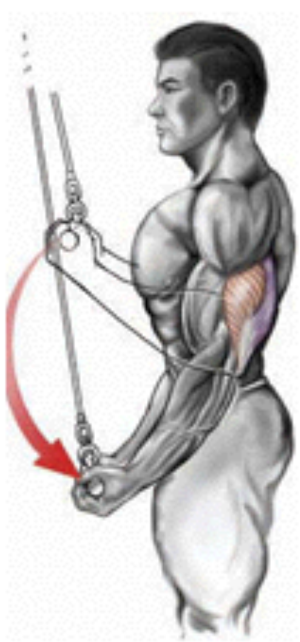
Further, the plain through which the forearm (as the operating lever of the Biceps) travels, is aligned with the origin and the insertion of the biceps - and also with the direction of resistance, and the direction of movement. This alignment is **not** an incidental aspect of the exercise. It is essential, for maximum efficiency.

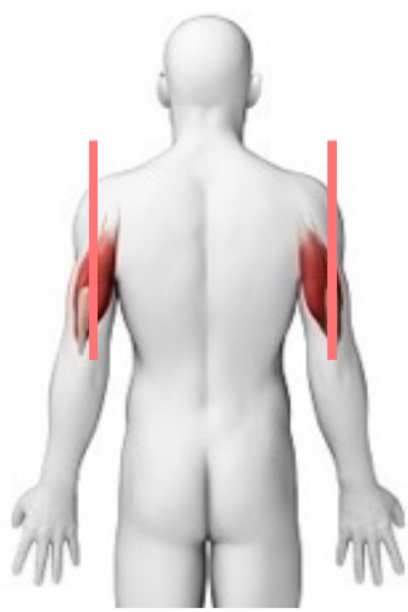
In the photos below, notice that the forearm travels through the plane, with which the Biceps origin and the Biceps insertion align. The upward movement (forearm trajectory) is on the same plain as the downward resistance. This is as it should be.



The same can be said for all “good” exercises, even though we often overlook the importance of this **requirement**.

When we do Triceps Pushdowns, we again comply with this principle, even though we may not be entirely aware of it. The cable provides an **upward** resistance, and we “oppose” it by pushing directly opposite that resistance (**downward**) - through the **same plain**. In addition, the plain through which the resistance and the movement occur, also aligns with the the **origin** and **insertion** of the Triceps.





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In the Anatomy section of this book, we will closely examine the Origins and the Insertions of ALL the Physique Muscles, as well as the direction of those muscle fibers. We will also examine the apparent design of the joint over which those muscles cross. These factors will inform us of what is the “primary function” of those muscles (the “ideal anatomical movement” those muscles produce) - which then suggests the ideal “pathway” the operating levers of those muscles should take, during a “good” exercise.

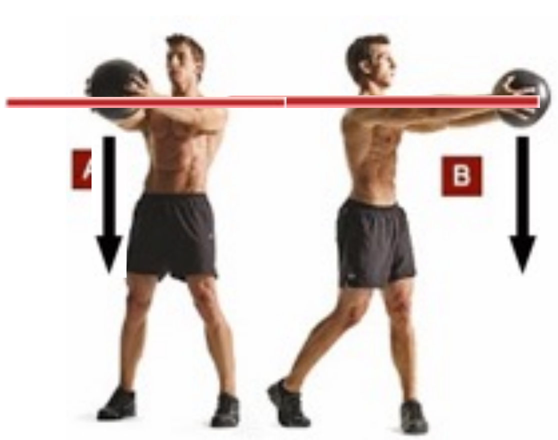
Therefore, we won’t spend too much time discussing muscle origins and insertions in this chapter. Rather, we will focus here on the alignment of the three other factors - the **direction of movement**, the **direction of resistance**, and the **operating lever** of a given target muscle.

Alignment of Movement and Resistance

The concept of “Resistance Exercise” is based entirely on the principle of challenging a muscle with an opposing resistance, thereby causing it to adapt. If it were it not for an **opposing** resistance, a muscle would be unchallenged.

An “opposing resistance” refers to a load that is pulling in the **opposite** direction of a movement. This may seem like a very obvious requirement, yet we sometimes see people NOT using a resistance that is pulling opposite their movement, during an exercise.

In the photos below (man on left & woman on right), we see two versions of a “*Torso Rotation”*. The muscles that produce this horizontal movement are the **Internal** & **External Obliques** and the **Tranverse Abdominis**.



We rotate the torso to the left, and then to the right. However, this resistance (above) - provided by a weighted “medicine ball” - is being pulled downward - **vertically**. Therefore, the horizontal movement - and the muscles that produce it - are entirely unchallenged. There is no horizontal resistance, opposing the movement.

Instead, the muscle(s) that are preventing the ball from falling toward the ground, are the ones that are being challenged by the weight of the ball. These include the shoulders (Deltoids), Biceps, Trapezius, lower back, etc., but these are not the focus of this exercise. Nor is this exercise the ideal way to work the Deltoids, Biceps, Trapezius, lower back, etc.

This exercise, therefore, is severely compromised - producing NO benefit to the *Torso Rotation* muscles, and insignificant benefit to the other muscles. Yet we see this exercise commonly performed in gyms, recommended by trainers, and demonstrated in fitness magazines.

The solution is simple. Switch from using a weighted ball, to a cable that pulls from either one side or the other (shown below), as you rotate the torso in the opposite direction of the cable’s pull. It must be performed in TWO separate movements because it’s TWO separate muscles. The left side muscles pulls to the left, and the right side muscles pull to the right.

Notice that NOW, the direction of resistance, and the direction of movement, are on the same plane. They are aligned - as they should be. Compare this with the previous example, using the medicine ball.

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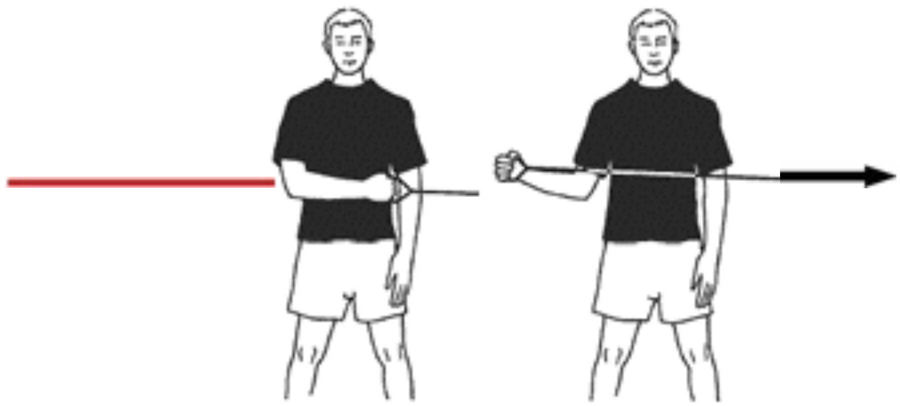
We often see people in the gym performing what is considered a (Shoulder) Rotator Cuff exercise, like the one pictured below. However, as you can see, the **same** problem occurs here, as is demonstrated above. The resistance (the weight) she is holding in her hand is NOT pulling in the **opposite** direction of her movement. The movement is **horizontal,** but the resistance is **vertical**.

Like the example above, she is actually performing two movements. In this case, she is doing an inward rotation of the humerus (upper arm bone) and an outward rotation of the humerus. These two motions are produced by two different set of muscles. However, in the example above, neither movement is being challenged.

Instead of her "**inward** shoulder rotators" working against an **outward** resistance, and her "**outward** shoulder rotators" working against an **inward** resistance, her Biceps are the muscles that are working - preventing the weight from falling to the ground. But this is NOT intended to be a Biceps exercise (nor is it a good Biceps exercise). Her horizontal (shoulder rotation) movements are not challenged at all. This is completely foolish.

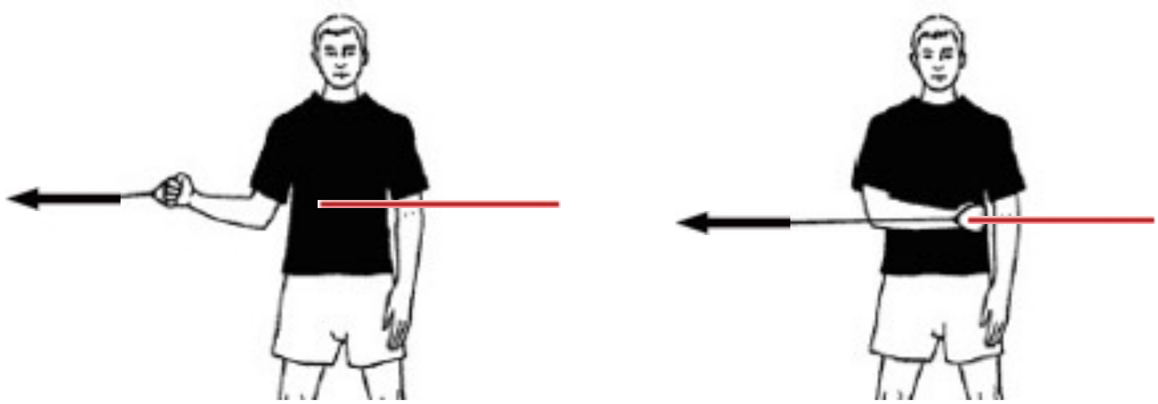
Sometimes we see a person doing this "worthless movement" (above) using both arms at the same time. But, in fact, working the "internal" and "external" shoulder rotators needs to be done in four separate movements - not one.

Below we see an “External Humeral Rotation” with the right arm. The resistance (in this example) comes from the elastic band, which is pulling from the man’s left side, as he rotates against it, to the right. He would then turn around, and do the same movement with the left arm, with the resistance pulling from the right.



Below, we see “Internal Humeral Rotation” with the right arm. The resistance is pulling from the left, as the man pulls his arm inward (toward the right). Again, he would then turn around, and perform the same motion, but with the left arm. The resistance would then be pulling from the right, as he pulls his left arm inward (toward the left).

In these two examples, there is ALIGNMENT between the direction of movement and the direction of resistance. They are both on the same plane.



Of course, this exercise can also be done using conventional pulleys (cables). What is essential, is that the resistance pull in a direction that is **opposite** the concentric movement of the limb in play - or that we pull directly opposite resistance.

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In the above examples, it's very obvious that there is a lack of alignment between the direction of movement, and the direction of resistance. When the resistance is vertical, there is ZERO load on the muscles that are performing a horizontal movement. Let us now look at some examples where the difference between the direction of movement, and of resistance, are not quite as obvious.

In the illustration below, we see a man performing a Supine Dumbbell Press **im**properly. It's "improper" because his **direction of movement** is NOT on the same plane as the **direction of resistance**. His humerus (upper arm bones) - the operating levers of his Pectorals - are also not aligned with the direction of resistance.

The mis-alignment demonstrated above is not quite as drastic as the "vertical and horizontal" example demonstrated earlier. Here, we have a case where the direction of resistance is 90 degree (on a protractor), while his direction of movement is approximately 70 degrees. This still results in a reduction of load to the target muscle - with the amount of that reduction then being transferred to other, non-target muscles.

Using simple math (rather than the Trigonometry formula typically used in engineering, but good enough for our purposes here), a 20 degree discrepancy from perfect alignment (in this exercise) would result in (approximately) a 22% dilution of the load from the Pectorals. That 22% of the load transfers to other muscles which would otherwise be mostly neutral, if perfect alignment were maintained. This results in a diminished efficiency to the target muscle (cost / benefit), and could also result in increased injury risk.

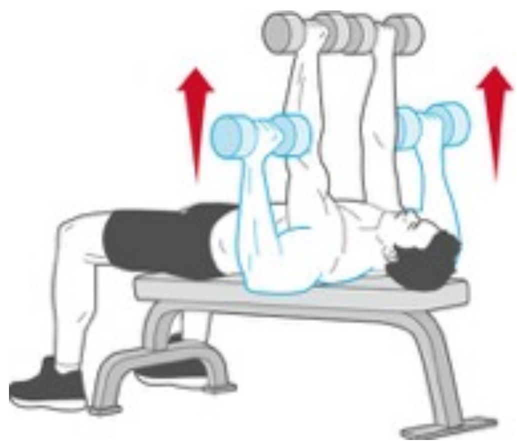
By creating a movement that is not aligned with the direction of resistance, we also cause that secondary lever to become active in a plain that was not intended. In the photos below, we see what happens when we tilt the forearm toward our feet, and toward our head - when intending to perform a *Supine Dumbbell Press*.

Given the amount of weight typically used for the purpose of working our Pectorals (average 40 pounds per arm, for men), an internal rotation of the humerus (shown above left) or an external rotation of the humerus (shown above right), could be like using a wrench to torque (turn) a bolt. The shoulder rotator muscles are much smaller, and less strong, than are our Pectorals.

Perfect alignment in resistance exercise also requires that **the origin and insertion of the target muscle**, be in line with the direction of movement, the direction of resistance and the operating lever of the target muscle.

Below, we see what this would look like if we were to look downward, through the plane of resistance, and of the direction of movement. We can easily see that there is ALSO alignment with the Pectoral muscle's origin on the sternum, and the Pectoral insertion on the humerus, and the operating lever of the Pecs (the humerus).

This is not a coincidence. It is the only way to **fully** load a target muscle. Any deviance from this alignment will result in a proportional diminishment of the load to the target muscle, and a commensurate transference of load to other, non-target muscles.



Because there is alignment between the direction of movement, the direction of resistance, the humerus and the origin / insertion of the Pecs, 100% of the downward force caused by the dumbbells (free weight) is being loaded onto the Pectoral muscles.

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Let’s look at another exercise - “Supine Dumbbell Triceps Extensions” - showing alignment, and the absence of alignment. While we’re at it, we’ll see which angles are best for evaluating the alignment of an exercise.

Below, we see a **side view** of this exercise. This allows us to see where, in the range of motion, the forearm “crosses” perpendicularly with gravity. We can see where the operating lever is most active, and least active. However, this view does **not** allow us to see, very clearly, whether or not there is perfect alignment.

When viewing an exercise for the purpose of checking **alignment**, we must view it from a perspective that allows us to see “planes” of movement and of resistance - as represented by **straight lines**. The side view shown above allows us to see the **arc** of the resistance curve, but not the “plane” of resistance or of movement.

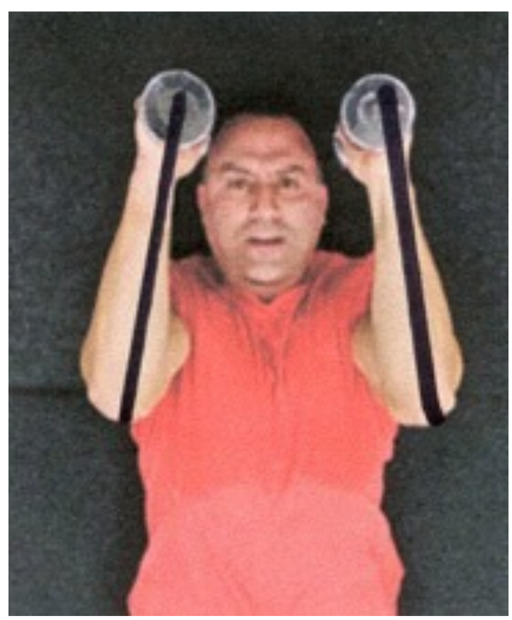
If you go back up and look at the photos of Arnold Schwarzenegger doing the *Barbell Curl*, you’ll notice it’s not a side view. We can thus draw a **straight line** through the plane of movement, and the plane of resistance.

The same is true when analyzing the *Triceps Pushdown*. A side view would allow us to see the arc of the resistance curve, but **not** the planes of resistance or of movement. A front view, however, would allow us to see the plane of movement and of resistance, as represented by straight lines. An overview head view also would allow us to these.

Getting back to the Supine Dumbbell Triceps Extension, the photos **below** show this exercise from a perspective that allows us to see the plane through which gravity pulls, as well as the plane through which the movement travels. If properly aligned, these two planes will overlap with each other, and appear as one line.

As we can see below, it does precisely that. The up arrow (of concentric movement), and the down arrow (of resistance), are on the same plane. Notice also that the origin of the Triceps (located on the posterior side of the shoulder) and the insertion of the Triceps (located on the forearm - just behind the elbow) are also on that same plane. This is perfect alignment.

Below is a different perspective of the same exercise. Again, we see a line - representing the plane through which the concentric movement travels, as well as the direction of resistance. That same line (one for each arm) overlaps with the origin and



insertion of the Triceps, and also with the operating lever of the Triceps - which is the forearm. Again, this shows perfect alignment.

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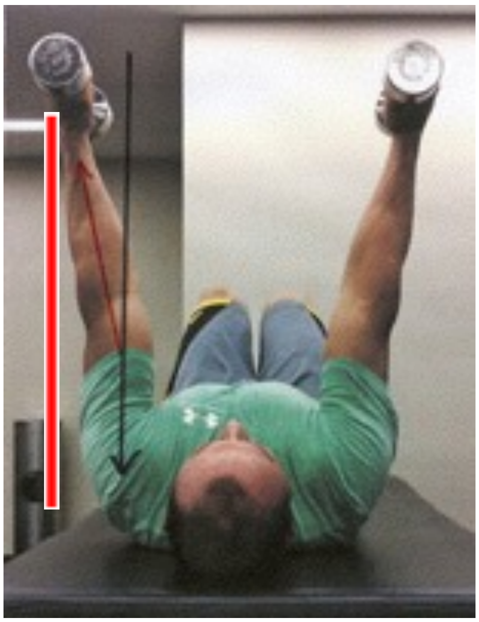
Let us now see what **<u>mis</u>alignment** looks like, viewing the *Supine Dumbbell Triceps Extension* from these two types of perspective.



The photo above-**left** shows the extended position - elbows straight - and the photo above-**right** shows the recoiled (aka the "descended") position - with elbows bent.

We can clearly see that the plane representing the direction of resistance (i.e., gravity / vertical) is not aligned with origin and insertion of the Triceps, nor with the operating lever of the Triceps (the forearm).

Since the humerus and forearms are not perfectly vertical (in this example), they are not neutral - in regard to lateral "activation". The left arm is tilting to the left of the **Apex**, which means that the left Pectoral muscle is now slightly loaded from the lateral tilt of the humerus. Where is that load coming from? Whereas the load was primarily loading the Triceps when alignment was good, the load is now starting to be diluted from the Triceps and is being disbursed to other non-target muscles, including the Pecs.

In this overhead view (above), we can see this misalignment from a different perspective. The photo on the left has a line on the weights, showing the plane of resistance. Those weights are being pulled **straight down**, from those lines - by gravity. However, the operating levers (the forearms), the elbow, the origin and insertion of the Triceps are not on the same plane at the direction of resistance.

If we angled our view slightly from each side, and peered through the plane of each arm, we'd be able to see alignment of the weight, the elbow, the origin and insertion of the Triceps - but NOT of the direction of resistance. The direction of resistance is "the boss". It's doing the pulling, and in the absence of proper alignment, it will pull the arm in an unbalanced direction, and shift load away from the Triceps over to the Pecs and the shoulder rotators, and twist the humerus in the shoulder socket.

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Alignment is important in every exercise. Anytime there is movement and resistance, there is the issue of whether or not those two "directions" are on the same plane. Even if the movement does not qualify as an "ideal anatomical movement" for a particular muscle, having the direction of limb movement and the direction of resistance on the same plane is vital to prevent the twisting of joints, and the inadvertent loading of muscles that cannot handle that joint rotation.

For example, in the illustrations below, we see two different directions of movement. The illustration below-left, shows a straight forward direction of movement, and a pulley that is directly behind that direction of movement. You can see that the cable is parallel with movement, and also with the humerus and forearm.

In the illustration below-right, the direction of movement has been changed to a slightly upward (incline) angle. Wisely, the pulley has been lowered, so that the direction of resistance is still on the same plane as the direction of movement. The cable is again parallel with the humerus and the forearm, so there is no twisting of the humerus. Regardless of whether or not the movement is the "best" for a given muscle, at least make sure the direction of movement and of resistance, are aligned.

As we'll learn later in this book, the incline angle (depicted in the illustration above-right) is not the best angle for the Pectoral muscles. You'll later see that an incline angled movement fails to have alignment with the origin and insertion of the "upper Pecs", so any Incline Press will be at least partly "wrong", even if the movement and the resistance are on the same plane.

Perfect alignment requires that ALL of these features be on the same plane - the movement, the resistance, the operating lever, the joint of the target muscle, the origin and insertion of the target muscle. Any deviation from that will result in a loss of efficiency, and an increased risk of injury.

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Summary

When we identify the origins and insertions of all the physique muscles, the concept of alignment will be more useable. But, for the time being, let's at leasts establish that there needs to be alignment between the direction of movement and the direction of resistance. If the movement is horizontal, a vertical resistance is essentially useless. If a movement is angled at 45 degrees, the resistance has to angle the same way, and parallel with the movement.

Efficiency refers to the best "cost/benefit" ratio. Performing an exercise that is inefficient because it lacks alignment, means you'll disburse the load in such a way as to "deprive" the target muscle, and transfer it to other muscles and joints.

This will result is more energy being expended than is necessary, with less reward. It's like having your car wheels in mud, where your traction is compromised. You could be revving your engine with enough force to make your car travel 50 miles per hour, but because your tires aren't getting good traction, you're only advancing at the rate of 30 miles per hour - but still spending the same amount of fuel as if you're traveling 50 miles per hour.

Exercises that are without alignment, are not **entirely** "unproductive". Movement is always productive, to some degree - even if it isn't "maximally productive" for building muscle, and even if there is an increased risk of injury. However, building one's physique is much more efficient if one can fully load a target muscle without compromise, without wasting energy unproductively, and without producing or increasing risk of injury.

Chapter Eight

Opposite Position Loading

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In order for a target muscle to be maximally loaded by the resistance you've selected for a given exercise, that muscle must be positioned directly opposite the direction of the resistance.

A muscle that is NOT positioned directly opposite resistance, will NOT be fully loaded by that resistance.

Often, a non-target muscle is mistakenly positioned directly opposite the resistance. In those cases, that non-target muscle will be the most loaded by the resistance, even though you may not intend it to be.

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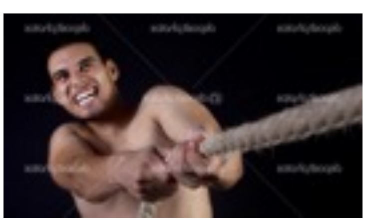
Consider the "Leaning Tower of Pisa". Suppose it was your job to prevent that Tower from falling, using a very strong rope, and sufficient physical strength. On which side of the Tower would you position yourself with that rope? The answer is, "**directly on the opposite side of the Tower's lean**". It would be mostly **futile** for you to stand anywhere else.

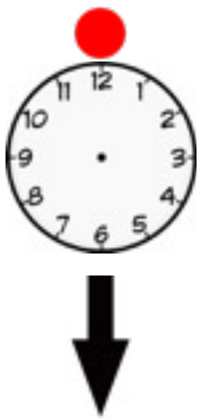


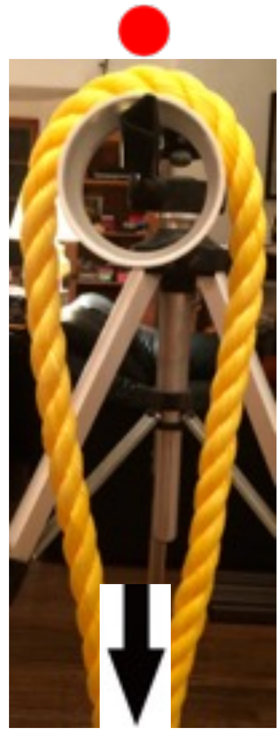
The most productive place for you to position yourself, with your rope - in your effort to prevent the tower from falling - is EXACTLY **opposite** the direction of the Tower's tilt. If the Tower were leaning directly **North**, you must position yourself directly **South**. That is where you would be most effective, because **that is where the greatest percentage of the load** of a North-leaning tower would be. A **very** small percentage of the North-leaning load would fall on the East side or the West side of the Tower.

Let's look at this from a different perspective.

Let's say that you have a rope, and you throw it over a tree branch. Then you grab hold of both ends of the rope, and pull them **straight down**, in a 6:00 direction.

Where (on that tree branch) would the greatest rope pressure be? It wold be at the 12:00 mark - directly **opposite** your direction of pull.





Although there would be a small amount of rope pressure on the branch, at the 3:00 position and 9:00 position, it would be a fraction of the amount - maybe as little as 25% - of the pressure that is at the 12:00 position. Obviously, ZERO rope pressure would be on the 6:00 position of the tree branch.

Now, let's say that you WANT to apply the greatest pressure on the branch at the **2:00** position. You will NOT be able to do that, by pulling in a 6:00 direction. You would need to change your direction of your pull, relative to the branch.

In order to deliver the greatest amount of your force (load) onto the 1:30 position of the branch, you would need to pull from an **7:30** direction (photo below).

This physics principle is universally true, including in resistance exercise. However, we often perform exercises that FAIL to provide the **ideal direction** of resistance, for the muscle we intend to work. Or, we FAIL to **position our target muscle** at the best angle, relative to the direction of resistance. As a result, we may only deliver a small percentage of the available resistance to the target muscle, while a larger percentage of the load is delivered to a muscle we **do not intend** to load.

To be clear, it is the ORIGIN of the target muscle, that should be positioned directly opposite resistance. This is based on the fact that **"<u>all muscles pull toward their origins</u>"**. If the origin of the muscle is not positioned opposite resistance, that muscle will be compromised in its ability to full participate in the pulling of that load.

If you perform an exercise that provides a 12:00 direction of resistance, but the origin of your target muscle is positioned at 4:00 - your target muscle will NOT get the full amount of that load. What will get the largest percentage of the load will be whichever muscle is positioned at 6:00 - even though you may not be aware of it, and even though you may not want that.

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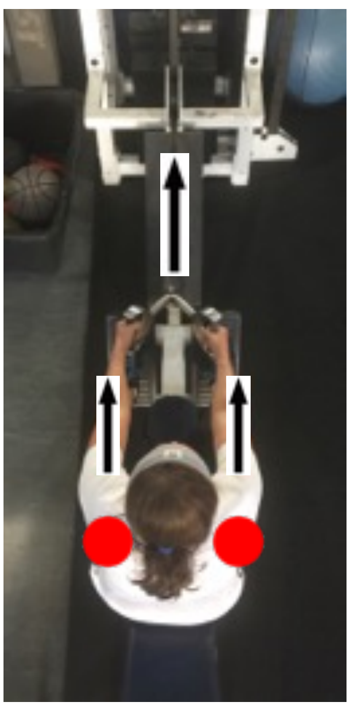
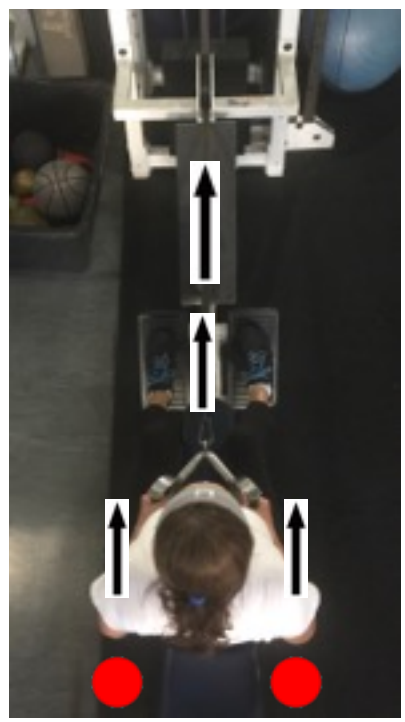
One Example

Since the early days of bodybuilding (the late 1800s), people wanting to work the muscles of their "upper and middle back" have typically performed various types of "**Rowing**" exercises - *Bent Over Barbell Row, One Arm Dumbbell Row, T-Bar Row* and *Low Pulley Row*. Today, over 100 years later, little has changed, in terms of which exercises are **thought** to be "the best", for development of the middle and upper back. However, <u>**none**</u> of the standard Rowing exercises are maximally efficient, because they fail to comply with the principle of "Opposite Position Loading."

Let's look at the mechanics of Rowing exercises, with three things in mind - 1) the **direction of the <u>resistance</u>**, 2) the position of the target muscles (more specifically - <u>the **origin** of the target muscles</u>), and 3) the direction of the exercise's <u>movement</u>.

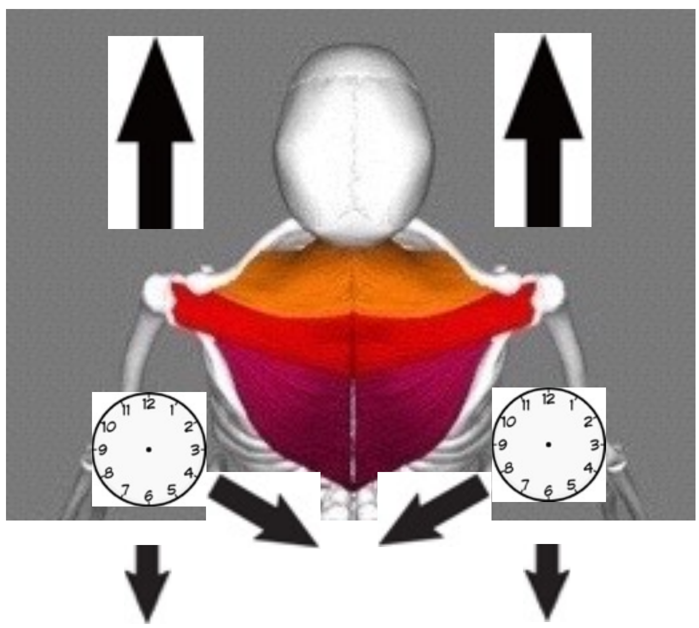
Rowing exercises typically provide a FRONT pulling resistance - like the *Low Pulley Row*, shown below (from an overhead view). Let's call it the "12:00 direction". Therefore, the most productive place to position the origin of the target muscle is **directly opposite** the frontward pulling resistance. That would be the 6:00 direction.





However, the origin of the Latissimus muscle fibers, and of the middle Trapezius muscle fibers, are on the spine. Relative to the 12:00 direction of resistance, the spine is positioned at 4:00 of the left arm, and 8:00 of the right arm. Not the 6:00 position (straight behind the arm). Which means - as per the calculation above - the Latissimus and the Trapezius will only be loaded with about 1/4 to 1/3 of a forward pulling resistance.

In the illustration below, we see a person facing the 12:00 direction. When the arms are outstretched forward, they will each be holding a resistance that is coming from the 12:00 angle, when performing a *Low Pulley Row*. In this illustration, we can see that the Latissimus muscle and the Trapezius muscle both originate on the spine. Look at the two, large (arm) arrows indicating the frontward pull of resistance - "the 12:00 direction".   Now look at the two (muscle) arrows that are pointing toward the spine. Those two arrows indicate the only direction the target muscles can possibly pull, because they are pulling from the spine. However, the resistance is not coming opposite those arrows.



The Trapezius and the Latissimus cannot contribute much pull in a 6:00 direction (directly opposite the 12:00 resistance) - as indicated by the smallest arrows - because that is not where their origins are. "Muscles always pull toward their origins".

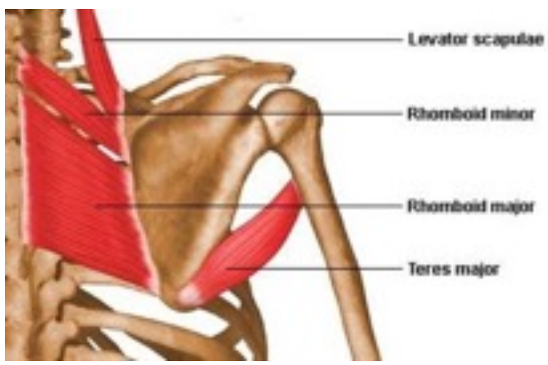
In the previous chapter, we discussed ALIGNMENT. We established that there needs to be alignment between 1) the direction of resistance, 2) the direction of movement, 3) the origin and the insertion of the target muscle. THAT is clearly **<u>not</u>** happening when we perform a standard Rowing movement.

Again - think of the "Leaning Tower of Pisa." Would you have stood on the East side or the West side of the Tower, in order to be in the BEST (most productive) position from which to pull in Southward direction - opposite the Northward pull of the Tower? Of course not. **This means that the Latissimus and the Trapezius - which are your TARGET MUSCLES during this exercise - are NOT in position to be the dominant force during an exercise that provides a forward pulling resistance.**

Other muscles, therefore, are forced to be the dominant load bearers. Whichever muscle is positioned directly opposite resistance, will be the most loaded - whether you intend it to be, or not.

Which muscles are the ones that are positioned directly opposite this forward pulling resistance? The Posterior Deltoids (primarily) and the Teres Major (secondarily). They are the only two muscles that are able to pull on the humerus - with a significant degree of dominant force - **toward a 6:00 direction**.

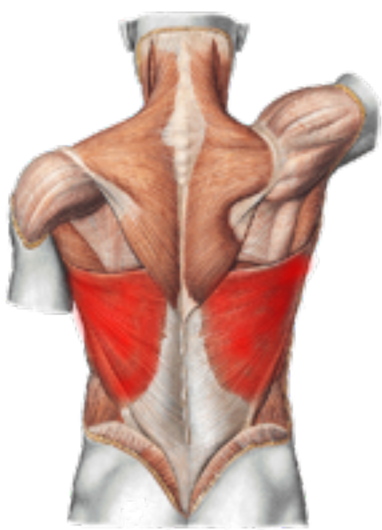
In the illustration below, you can see where the Teres major is. It's a relatively small muscle, but positioned in line with the forward-pulling (12:00) direction of resistance and the posterior-pulling (6:00) direction of the humerus, through the shoulder the joint.

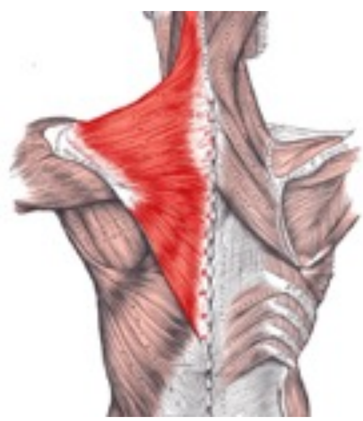


Another way of understanding this concept of "direction of resistance" relative to the "direction of movement", is by thinking of a Marionette Doll.

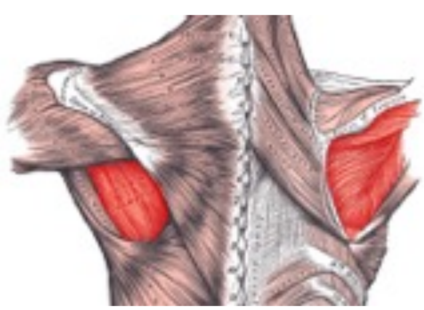
If you were the Puppet Master, controlling the movement of the Puppet's arms, and you wanted to make it perform a "Rowing Motion" with its arm, from which direction would you pull the string that is attached to its arm? You would have to pull from a position that is along the same path as the movement you want to create. You would pull from the 6:00 position (posteriorly). You would NOT pull on the left arm from a 3:00 angle, from the middle of the puppet's back (spine). Yet, that is the only angle from which your target muscles (Lats and middle Trapezius) can pull.

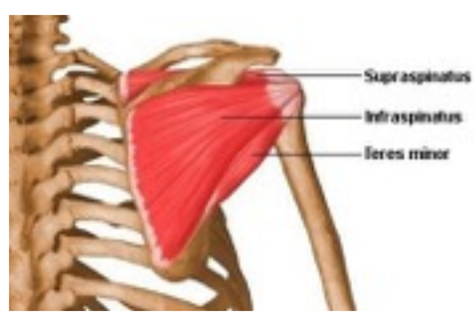
As we'll explore more fully in the Anatomy Section of this book, the two most significant muscles of the "middle and upper back" are the Lats and the Trapezius. They occupy the largest areas of the back. The Infraspinatus and Teres minor DO NOT participate much during a Rowing Motion. They perform humeral **rotation**.



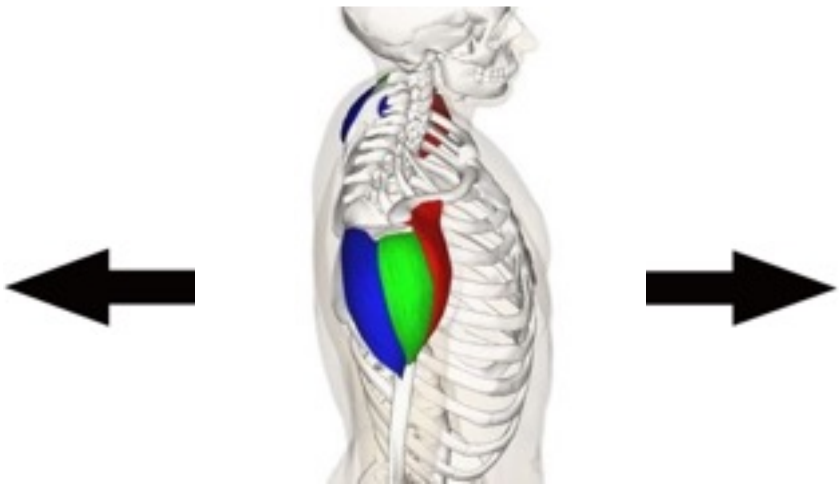


In the illustrations **above**, you can see that the Lats (on the left) and the Trapezius (on the right) occupy most of the back, and they both originate on the spine.



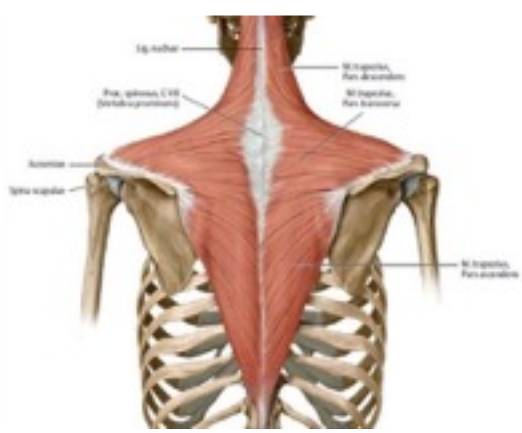


The Infraspinatus (**above-left and right**) and Teres minor (**above-right**) are tucked in between the Trapezius and the Lats (from a visibility standpoint), but neither of them have any real **leverage** on the humerus. As you can see (in the photo above-right), they both connect to the HEAD of the humerus. Therefore, they are only able to ROTATE the humerus. They're not able to participate much in pulling the humerus backward, as one would during Rowing.



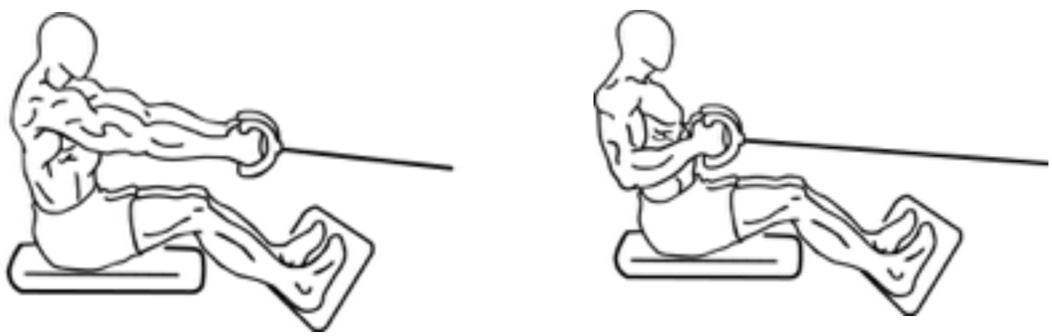
In fact, the Posterior Deltoid (in blue, above) is the **only** muscle that is in a **primary** position for optimal loading, from a forward pulling resistance. The Teres major is a little **less** well positioned, but still in a better position than are the Lats or the Trapezius.

It should also be noted, that the Trapezius DO NOT connect to the humerus at all (see illustration below). So, they are completely UNABLE to participate in the "arm part" of the Rowing movement. They originate on the spine, and attach to the scapula (shoulder blade). The Trapezius' primary job (function) is to pull the **Scapula** inward backward, toward the spine.

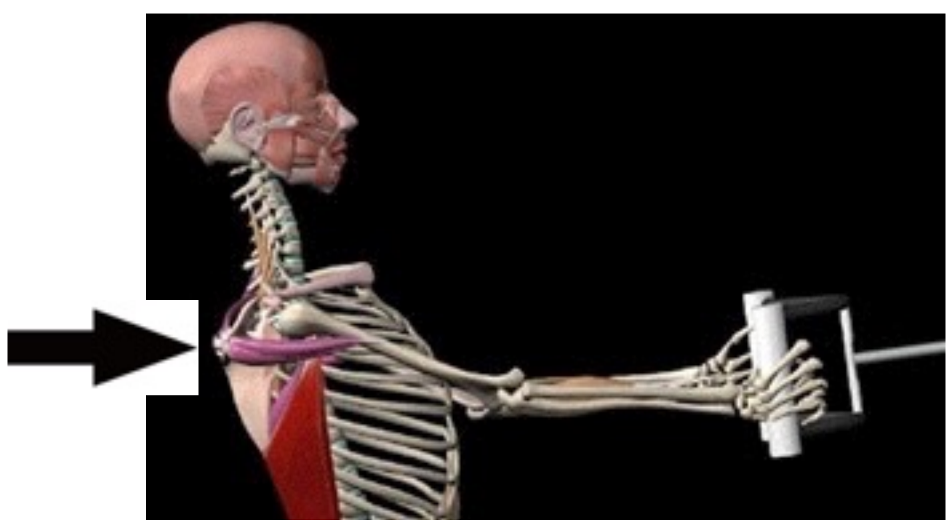


Yes - part of the Rowing movement involves "pulling the shoulders back." But, it's obvious that the largest part of the Rowing movement involves the arms - not the scapula. This means that **a standard Rowing movement is NOT the ideal movement, nor is it the ideal direction of resistance, for optimally loading and developing the Lats or the Trapezius.**

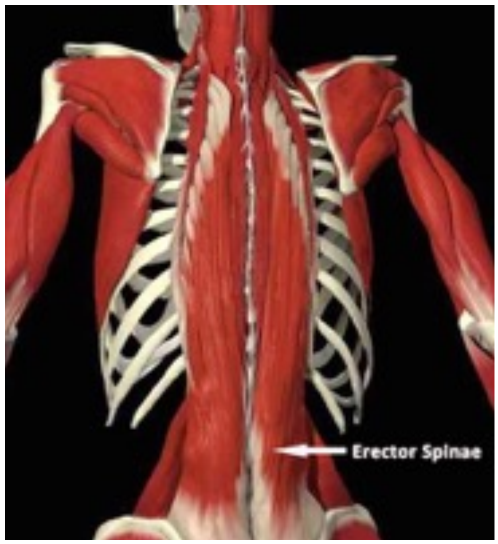
The next time you see someone doing a Seated Cable Row (shown below), observe that their primary motion is their arms pulling backward - not inward, toward the spine - and there is very little scapular retraction. Often, none.



Also, the next time you **do** a Rowing exercise yourself, pay attention to the Load you feel on your Posterior Deltoids. We tend to ignore the fact that we feel a considerable amount of **Load** and **fatigue** in the **Posterior Deltoid**, when we perform any Rowing exercise. But it's obviously happening, and to a much greater degree than our Lats and Trapezius.



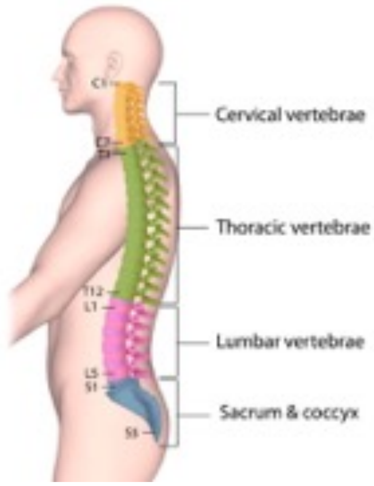
There is ONE OTHER muscle that is also positioned directly opposite resistance - and is therefore optimally loaded by the forward pull of *Seated Low Pulley Row* - the “Lower Back” (Erector spinae). Again, whatever muscle(s) is/are positioned directly opposite resistance, will be most loaded - whether you intend it to be or not. As the two arms are pulled forward, they pull the entire torso forward as one unit. Were it not for the Erector spinae group (running up the entire length of the spine), the torso would fall forward like a rag doll.

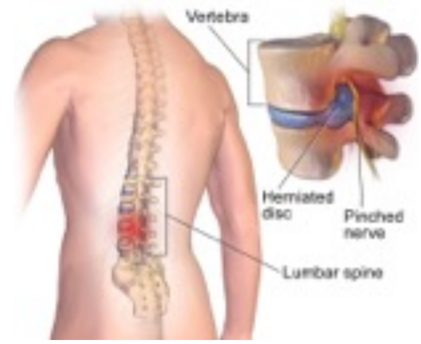


Certainly, it is NOT the intention of someone performing a *Seated Low Pulley Row*, to maximally load their lower back (nor their Posterior Deltoids) - but that is exactly what’s happening with a forward pulling resistance. It’s receiving **100%** of the forward-pulling load (unless you’re using a chest-supported rowing machine, of some kind).

In addition to the Erector spinae likely being “over-loaded”, there is also the possibility that the user might round their back forward, as they perform one of the unsupported Rowing exercises (i.e., Unsupported T-Bar, Bent-Over Barbell, Seated Cable, etc.). An “over-flexed” (overly rounded) spine, combined with heavy forward resistance, could result in an intervertebral lumbar disc “herniation”. The herniation could then “pinch” (press on) a nerve, causing tremendous back pain.

The illustration below shows the vulnerable area - the Lumbar spine. The black arrow indicates the forward pull of a standard (unsupported) Rowing exercise. You can imagine how a heavy forward pull could force the spine to over-bend in a forward direction, thereby causing a Lumbar disc to push out toward the back.





When doing most of the standard (forward pulling) Rowing exercises, the muscles you DON'T want to strain (the Posterior Deltoids and the Lower Back) are getting 100% of the load, while the muscles you WANT to load (the Lats and middle Trapezius) are only getting about 30% of the load. It just makes no sense at all, bio-mechanically speaking.

The *Bent Over Barbell Row* is perhaps the **worst** (least efficient) of all the Rowing exercises, because - in addition to the weight of the barbell - **the Lower Back is also loaded with the weight of the torso** (i.e., a secondary resistance). So, not only are the Lats and Trapezius limited to only receive about 30% of the weight of the barbell, the Rear Deltoids are over-loaded with 100% of that weight, and the Lower Back is double-loaded with 100% of the barbell weight, **PLUS** the weight of the torso (which could be as much another 80 - 100 pounds).

To optimally work the Lats and/or the Trapezius, the **movement** should be inward (from an **<u>outward</u>** angle), and the direction of **resistance** should be directly OPPOSITE those muscle origins. The **origins** of these two muscle groups (located on the spine) need “Opposite Position Loading”.

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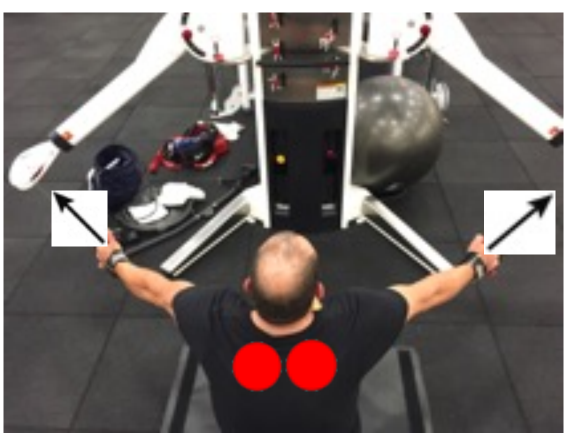
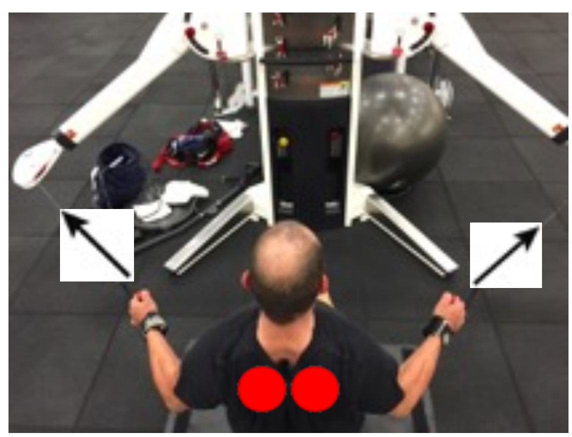
Here’s the ideal alternative - below. The direction of resistance is coming from a 45 degree angle (from each side), and is now more opposite the origins of both the Trapezius and the Latissimus. The Posterior Deltoids are now more to the side of the direction of resistance - rather than opposite it - so they’re much less loaded. The direction of humeral and scapular movement are more inward, toward the spine - toward the muscle origins. The combined pull (left cable and right cable) produce a composite forward pull that is approximately 30% LESS than a straight forward resistance - thereby relieving strain on the lower back. In other words, we’re getting MORE of what we want (Lats / Trapezius), and LESS of what we don’t want (Posterior Deltoids / Lower Back).





I call this movement, “**Scapular Retraction**”. It should not be called “Rowing”. This exercise does not (and should not) produce an emphasis on the arm movement that is typified by the rowing action used on a boat. Calling it “rowing” encourages that type of movement. The **primary emphasis** here should be on shoulder (scapular) movement - releasing the scapula forward (photos above-left), and then retracting (pulling back and inward) the scapula (photos above-right).

The secondary emphasis should be on the arm movement. The reason for this is that the Lats (which pull the arms - not the scapula), mostly pull the arms inward and **downward**, from a slightly more **elevated** angle. There is another, better Latissimus exercise, which allows better isolation of the Lats. This exercise does involve some Latissimus activity, but not enough to be a “stand alone” exercise for the Lats. However, this is the absolute best middle/lower Trapezius movement, due to its emphasis on scapular retraction and ideal direction of resistance.

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The exercise illustrated below - a “Barbell (or Dumbbell) Front Raise” - has always been considered an “Anterior Deltoid” exercise - but is it really? The answer comes by way of this principle - Opposite Position Loading.

In the photo below, I’ve outlined the Anterior Deltoids, in light blue. Now, let’s ask ourselves, “Are they positioned directly opposite resistance?” The answer is, “not quite.” The resistance is pulling straight down (“free weight” gravity) - the 6:00 direction. Therefore, the ideal position for the target muscle (for maximum loading) is the 12:00 position. As you can see, the Anterior Deltoids are positioned at 2:00 (right Anterior Deltoid) and 10:00 (left Anterior Deltoid). In other words, they are positioned to only receive about 30% of the load.

In the photo below, I've outlined the Lateral Deltoids in green. Now, let's ask ourselves, "Are they positioned directly opposite resistance?". The answer is, "yes - much more so than the Anterior Deltoids". They'll receive about 70% of the load. Therefore, the Lateral Deltoids will be more loaded with this exercise - even though it is intended to be an Anterior Deltoid exercise.

Again, the direction of the movement is not what causes a target muscle to be LOADED. In order to LOAD a target muscle, we must deliberately position that muscle so that it's opposite the **direction of resistance**. How do we do this?

The degree of arm (humeral) rotation is playing a role here, although it's not the only factor. By causing the palms of his hands to face downward, he is rotating his humerus such that his elbows are pointing laterally. This "inward" rotation of his arms is what's causing the Lateral Deltoids to face upward.

By turning the palms of the hands inward (hammer style) or upward - which causes the elbows to point downward (instead of to the sides) - the humerus is externally rotated. This causes the Lateral Deltoids to rotate away (to the sides, toward the 2:00 position) - and rotates the Anterior Deltoids to the 11:00 position - closer to ideal. This now places them in a more dominant position to be loaded by the resistance.

This version of a "Front Raise" is better than the "palms down version" shown earlier. We've now positioned the target muscle more in line with the direction of resistance and also with the movement (pathway) of the muscle's operating lever. However, notice that the Anterior Deltoid is NOT actually in the 12:00 position until the arm is raised up. The **Anterior Deltoid is in the 3:00 position** at the beginning of the movement (see his right arm). This means that the target muscle is not opposing resistance UNTIL the end of the range of motion.

This means that the Anterior Deltoids are **<u>not</u>** being "Early Phase Loaded" in this version of the exercise. They are being loaded in the latter part of the Range of Motion. And - as we learned in Chapter 5 - it's better to load the early part of the range of motion, because a muscle is stronger when it's elongated.

So, although we have improved the mechanics a little bit by rotating the humerus externally, the "resistance curve" is not ideal with this kind of exercise. We need to change the direction of resistance, relative to our torso, so that the movement by the humerus, is "Early Phase Loaded".

With this exercise (above) - *Supine Front Dumbbell Press* - we're getting closer to ideal mechanics, for the Anterior Deltoid. Because the palms are facing upward (toward the head), the elbows are pointing toward the feet, and the humerus is rotated so that the Anterior Deltoids are positioned opposite resistance. And, because the resistance is now coming from "behind us" ("posteriorly"), rather than from the direction of our feet ("inferiorly" - when we're standing or seated upright), the resistance curve is ideal - it is heavier at the beginning of the range of motion, and lighter at the end of the range of motion.

Of course, the Anterior Deltoids don't "know" whether the elbow straight or elbow bent. The Anterior Deltoids only pull on the humerus, and don't "care" whether we're using a longer lever (straight arm / more magnification) with a lighter weight, or a shorter lever (bent arm / less magnification) with a heavier weight. Therefore, this exercise could be done either way - although using a bent arm (i.e., a pressing motion) bypasses the potential strain on the Biceps and Biceps tendon (straight arm).

This is an excellent Anterior Deltoid exercise.

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Summary

There are many examples of this "failure" to properly position the target muscle, and the direction of resistance, directly opposite from each other, in traditional resistance training. But many of these exercises have been around for so long, few people question their effectiveness.

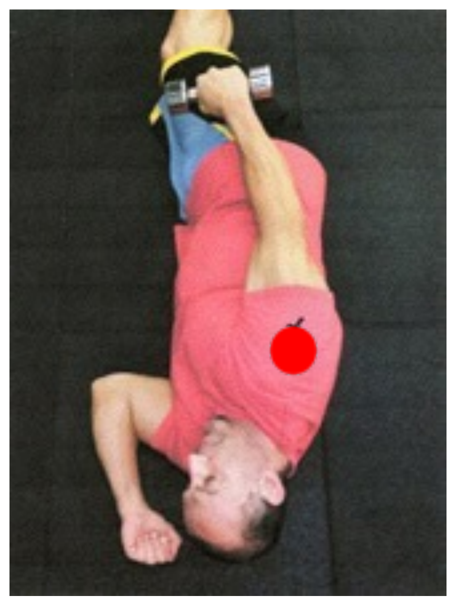
The principle of "Opposite Position Loading" allows us to understand what muscles are loaded during an exercise, and which ones are not. It also allows us to determine how much (approximately) a muscle is loaded, on a percentage basis.

If a muscle is directly opposite resistance, it is positioned to receive the largest percentage of the available load (100%), but if it's positioned to the side of the opposing resistance, it may only be loaded with half, or a quarter, of that resistance.

By positioning a target muscle directly opposite resistance, and non-target muscles in positions that are not opposite resistance, we are able to maximize our efforts and minimize wasted energy.

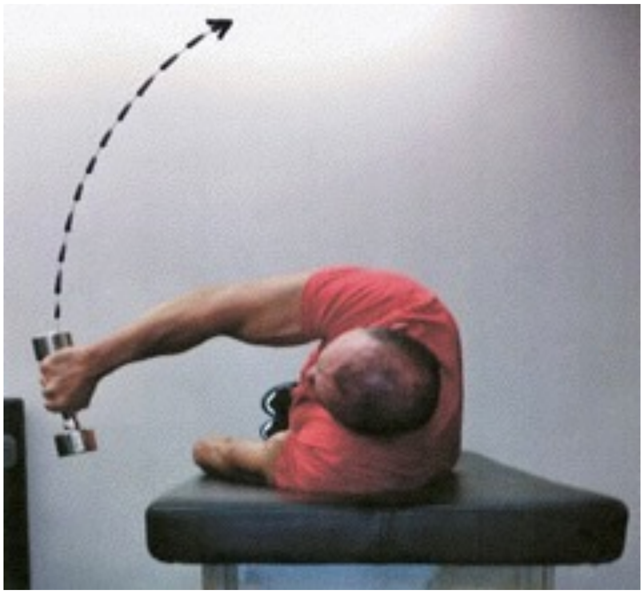
In the beginning of this chapter, I could have asked, "If the Tower is leaning directly North, where would the load be?". The answer would be, "directly South" - opposite the direction of pull. Let's see how this applies to resistance exercise.

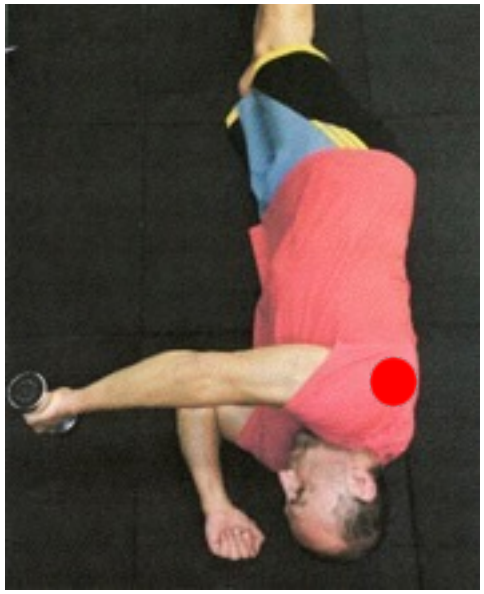
In the photos below, I am performing a "Lying Side Dumbbell Raise". Think of my right arm, in this example, as a type of Tower. When it's UP, it's vertical. As I bring it down, let's assume I do so in a **Northern direction**. The load, therefore, would be opposite that lean - directly on my Lateral Deltoid, positioned on the **South side**.



This is precisely what makes this exercise a "Lateral Deltoid exercise". The eccentric movement of my arm is opposed (resisted) by the muscle that is opposite the direction of my arms's movement - the Lateral Deltoid. The concentric movement of my arm occurs as a result of my Lateral Deltoid pulling it from a position that is opposite the downward force of my weighted arm. This is just like the example of the "Leaning Tower of Pisa".

Now, in the photos below, I've tilted my arm (the "Tower") in a **Western** direction. So, the load now shifts to the **East** side of this "Tower". The Posterior Deltoid is now loaded, because IT'S in a position that is opposite the "tower's" lean. I have selectively loaded a different muscle, simply my changing the direction of this "Tower's" lean.





Finally, let's see what happens when I lean this "Tower" (my arm) in a direction that is BETWEEN North and West - in a **Northwestern** direction.

What we “discover” is that the load falls on both - partially on the Lateral Deltoid (black line) and partially on the Posterior Deltoid (black line). Each muscle is “sharing” a percentage of the load. In other words, they are cooperating with each other, in a combined effort (red line).

This last example is not necessarily a “good” exercise, but it serves to demonstrate that a load always falls on the muscle(s) that is positioned directly opposite its lean (or pull).

As you can see, this “rule” of Opposite Position Loading coincides perfectly with the previous principle discussed - Alignment. You’ll recall that perfect alignment requires that the **direction of resistance** be “in line” with the origin and insertion of the target muscle. Obviously, this means that the origin of the muscle must be positioned directly opposite (by in line with) the direction of resistance.

Chapter Nine

Dynamic vs Static Muscle Contraction & Range of Motion

“Dynamic” muscle contraction occurs when a muscle lengthens and shortens, against resistance. This type of muscle contraction causes the joint over which that muscle crosses, to bend (flex or extend), thereby producing anatomical movement.

“Static” muscle contraction occurs when a muscle holds resistance, without lengthening or shortening. Instead of causing the joint to flex or extend, the muscle holds that anatomical position, without movement.

Generally speaking, dynamic muscle contraction is considered more productive for the purpose of muscle growth / physique development, as compared with static muscle contraction. It is also believed to be more “functional”, generally speaking.

Dynamic muscle contraction requires “Range of Motion” - but does not necessarily require “full” range of motion. For muscle building purposes, however, a relatively full range of motion is more productive than insufficient range of motion.

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When we speak of “bodybuilding” / weight training programs, we usually discuss the issue of “sets and reps”. Typically, we have a goal or a plan that involves a number of repetitions per set of an exercise, and a number of sets per muscle group.

The concept of “repetitions per set” is a system of measurement. Theoretically, it could be considered a “dose” of muscle stimulation, except for the fact that the amount of weight used plays a major role in how demanding that “dose” is - and that’s not standardized. Still, there is a general understanding that a set should produce a certain amount of muscle fatigue (stimulation), with given number of reps.

There are ongoing debates and studies related to the issue of whether “high reps” of “low reps” are better. Both have their separate benefits.

The point is that - for the purpose muscular development - the concept of **reps** (“repetitions” of movement of a given exercise) is an established and integral part of resistance exercise.   “Repetitions of movement”, against resistance, implies **Dynamic** exercise. There are no “repetitions” in Static exercise.

Muscle contraction in the absence of movement, is considered **Static** - or **Isometric** - exercise. The reason Isometric exercise is not used much, if at all, in bodybuilding or in general fitness programs, is because it has been proven to not as effective and Dynamic exercise. It does not “build” a muscle as well, and it primarily strengthens a muscle only in particular position - not throughout the muscle’s entire range of motion.

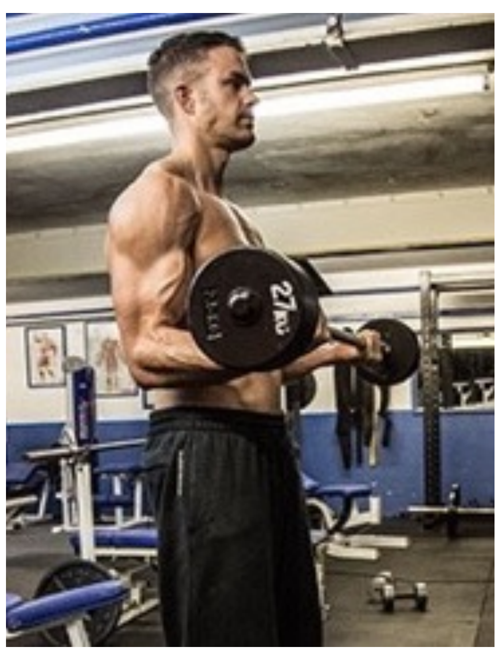
Isometric exercise is most often used in physical therapy programs, as a way of introducing “resistance” exercise to specific muscles, while avoiding the movement of a joint which may be injured.

In the photo below, we see an example of <u>**Static**</u> Pectoral muscle contraction, without moving the shoulder joint, as one would during standard resistance training exercises. The hands are simply pressed against each other, thereby causing the Pectorals to experience muscle tension.

There is no “range of motion” nor any “reps”. Typically, the contralateral tension is held for a count. Obviously, there is no way of establishing how much force is being used, because there is no object being lifted. Therefore, no specific threshold needs to be met. One must use their own, personal instinct, as to how much opposing pressure to use.

In the illustration below, we see a man performing an Isometric Anterior Deltoid exercise (right), and Posterior Deltoid exercise (right). In the illustration below-left, he is pushing his fist forward, against the wall, thereby creating Static muscle contraction in his Anterior Deltoid. In the illustration below-right, he is pushing his elbow backward against the wall, thereby creating Static muscle contraction in his Posterior Deltoid.

Isometric exercise can also be done with other free weights. One could hold a pair of 5 pound dumbbells out to the sides, with arms straight, for a time count (e.g., 60 seconds). Or one could hold a 30 pound barbell, with elbows bent at 90 degrees (at the mid-point of a “Barbell Curl”), for a time count.



When rehabilitating an injury, dynamic muscle contraction (with joint movement) may not be feasible. Often, an injury limits joint mobility. Thus, the concept of challenging a muscle without forcing a joint to move, has merit in such circumstances.

However, from a functional standpoint, exercise WITH movement naturally produces a more useful benefit, since it increases strength through a muscle's entire range of motion. Also, since Dynamic exercise involves elongation of muscles (stretching) against resistance, it's logical that flexibility would improve, as would joint mobility.

In terms of **muscle growth**, it seems clear that isometric exercise is not a very good training strategy. There has never been a competitive bodybuilder of any renown that has developed his (or her) physique, by way of isometric exercise. If muscular development could be achieved with isometric exercise, it would certainly have been demonstrated by now - given the degree of obsession that is often found in bodybuilding / physique development. Yet, not a single person has ever achieved that level of muscular development, using isometric exercise.

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However, **Dynamic** exercise **often** involves isometric **participation** of other stabilizing muscles, while the target muscle performs dynamic muscle contraction.

In the illustration above, we see a man performing a *Standing Barbell Curl*. His Biceps are performing the dynamic muscle contraction - lengthening and shortening, stretching and contracting. However, other muscles are stabilizing his upright position - isometrically. His lower back (Erector Spinae) is holding static tension, to prevent him from being pulled forward by the front-loaded torso. His Trapezius is loaded by the "opposite position loading" / downward resistance. His Gluteus and Hamstrings are also maintaining isometric tension by keeping him in an upright posture, against the forward pulling barbell. His forearm flexor muscles are keeping his hands in line with his forearms, even though the barbell is "trying" to bend his wrists back. His fingers are maintaining a static grip on the barbell, and the muscles of his calves and feet are also in some degree of activation.

So, although the Standing Barbell Curl may be regarded by some people as an "isolated exercise", there is much more going on than a simple Biceps contraction.

Granted, the muscles that are working isometrically - the Erector Spinae, Trapezius, Glutes, hamstrings, forearms, calves, hands and feet - are not getting as much benefit from their participation, as are the "dynamically working" Biceps. But they are still "working" to some degree, and receiving more stimulation than if the person were simply sitting idol.

As we'll learn in Chapter 14, participation by stabilizing muscles, during a given exercise, can be referred to as "Peripheral Recruitment". In this sense, almost all resistance exercises have some degree of Peripheral Recruitment - some more than others. In fact, it's often difficult to establish a difference between exercises that have been deemed "compound" from those that have been deemed "isolation".

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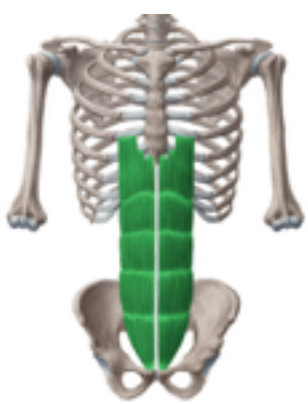
Dynamic is "Good" & Static is "Less Good"

Now that we have established that a muscle responds better to Dynamic exercise, than it does to Static exercise, let's look at some inconsistencies that exist in the fitness industry, in regard to this issue.

The *Standing Barbell Curl* is considered a "Biceps Exercise" - not a "Lower Back Exercise". This is because the Isometric contraction that occurs in the Erector spinae, as well as all the other participating muscles, is **not good enough** to make it maximally productive for those muscles. It is the **Dynamic** muscle contraction being done by the Biceps, that qualifies the *Standing Barbell Curl* as a "Biceps exercise". Dynamic muscle contraction is more productive than is Static muscle contraction.

Now, let's examine a *Lying Leg Raise* (shown below). This is considered an "Abdominal Exercise", but let's see what's working **dynamically** and what's working **isometrically**.

In the photos above, we see a man raising his legs from a horizontal position to a vertical position. Therefore, whatever muscle is raising his legs, is working Dynamically. That muscle is the "hip flexors" - NOT the Abdominals. In fact, the Abdominals cannot raise the legs - because they are not even connected to the legs.



In the illustrations above, we see the Rectus abdominis (the "abs"). Clearly, this muscle originates on the ribs, and attaches to the pubic bone of the pelvis. It does not attach to the legs, and does not even cross the hip joint. So, what role is the Rectus Abdominis (the "abs") playing in a Leg Raise of any kind? It's playing the role of spinal stabilization - the same role the Lower Back plays in Standing Barbell Curls.

So, why is this called an “Ab Exercise”, but the Standing Barbell Curls is called a “Biceps Exercise”? Do you see the inconsistency? If the stabilizing effect that the Abs have on the spine during L*eg Raises*, qualifies as an “Ab Exercise”, then *Standing Biceps Curls* should be called a “Lower Back Exercise”. And if the Dynamic work that is being done by the hip flexors, during *Leg Raises*, is insignificant enough to be ignored, than we should ignore the role of the Biceps during *Standing Barbell Curls*.

If we believe that “dynamic is good, and isometric is not so good” (and we have good reason to believe that), then a “*Leg Raise*” is NOT a good Abdominal exercise. It’s a Hip Flexor exercise.

Any type of *Leg Raise* - whether it’s performed while Lying on a floor mat, or while hanging from a Chinning Bar, or while suspended on a “Roman Chair” (shown below) - is NOT an efficient Abdominal exercise. Yes, the Abs are working - but **Isometrically**. So the benefit that they are getting is a fraction of the benefit the Hip Flexors are getting, because they’re working **Dynamically**.

Note: Some would argue that a Leg Raise is considered an “Ab Exercise” because (ideally) the pubic bone should be pulled toward the rib cage, as the legs are raised. However, this is also foolish. The Rectus abdominis contracts the same, whether the pelvis is pulled toward the ribs, or the ribs are pulled toward the pelvis. It’s much more cumbersome to pull the pelvis up - as compared with simply pulling the ribs down toward the pubic bone. This will be further explained in the Anatomy Section.

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The criteria that determines which muscle is working **Dynamically** versus **Isometrically**, is JOINT MOVEMENT. We first identify **where** the movement (i.e., joint flexion / extension) is occurring, and then we identify which muscles crosses that joint / articulation.

In order to cause Dynamic muscle contraction, we need bend the **appropriate** articulation, thereby causing the correct muscle to do the more productive work. In the Abdominal exercise I demonstrate below, I am deliberately bending (flexing) the spine, because that is that action the produces Dynamic contraction of the Rectus abdominis. Here, I am bringing the origin of the Abs (on the front of the ribs), toward the insertion of the Abs (on the pubic bone).

Of course, this is not the only exercise that produces spinal flexion and Dynamic contraction (elongation and shortening) of the the Rectus abdominis. But this exercise clearly demonstrates the action that is required to provide Dynamic contraction to the Abs. Compare the degree of spinal flexion occurring here, with the amount of spinal flexion occurring in the example of the Leg Raise above.

Also, take note, the **entire** Rectus abdominis is working here - from top to bottom. We'll explore this concept more fully in Chapter 11 - the "All or Nothing Principle of Muscle Contraction" - and also in the Anatomy Section.

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Another exercise that "confuses" which muscle should be working Dynamically, and which muscle should participate Isometrically, is the "*Lower Back Extension*" - shown below.

 

This exercise is intended for the Lower Back, but let's examine which muscle is contracting Dynamically, and which is working isometrically.

In the photos above, we see that the primary articulation (place of bending) is at the hip (red dot). Meanwhile, the spine is maintained rigid throughout the movement. The Erector spinae ("lower back" muscles) do not cross the hip joint, so they do not extend the hip. Hip extension is produced by another set of muscles (which will be addressed later).

The Erector spinae extend (move) the spine. Therefore, the spine should be bending where the green dot is - thereby allowing the muscle to produce Dynamic muscle contraction. The Erector spinae DO work, as demonstrated above. However, they only work Isometrically - and that is **not as productive** as Dynamic exercise.

This is another example of an exercise where we produce a "better" type of contraction (i.e., Dynamic contraction) for a muscle that is NOT our target muscle, and we produce an inferior* type of contraction (i.e., Isometric contraction) for the muscle which IS our target.

(Note: In this context, "inferior type of contraction" refers to stimulation that is LESS likely to produce muscle hypertrophy and less likely to produce strength through a broad range of motion.)*

Some people might think that if the exercise demonstrated above, provides better stimulation for the Gluteus, "Why not just use it - and regard it - as a Gluteus exercise?". However, the strength capacity of the Gluteus would hardly be challenged by the resistance provided in this exercise. Of course, one could add resistance (by holding a weight), in an effort to better challenge the Gluteus with this exercise. But there are better - and more comfortable - options for exercising the Glutes.

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If our goal is to target the Spinal Erectors (aka “Erector Spinae), we need to move the spine - not the hip joint. This can be done very easily, and need not involve the hip joint at all. In fact, it’s better to not involve the hip joint, when attempting to develop the Erector Spinae, because this is a movement that requires undivided attention. Most people tend to be out of touch with the way their spine moves - or “can” move - so they lack coordination of it. But with a little practice, it’s easy to gain that coordination.

The exercise below, is a “Seated Torso Extension”. First, we round the back - thereby elongated the Erector spinae. And then we “extend” (or “arch”) the back - thereby contracting the Erector spinae.

In this exercise (above), there is more movement in then spine, and less movement at the hip. In other words, the target muscle (the Lower Back / Erector Spinae) is now working Dynamically. Notice that I am staying entirely on one side of the Apex (indicated by the red line). I am not crossing over to the other side. Thus, I am keeping the same muscle loaded the entire time.

Care should be taken, when doing this exercise, to not “over round / flex” the spine, nor to “over extend / arch” the spine. The spine is made to move, but - just like any joint - has limits as to how much it can move safely. Never force any joint motion, and that includes the spinal movement. But some degree of movement in the spine is absolutely better than no movement at all - both for muscle development as well as mobility.

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So, when using this principle as part of exercise analysis, the questions to ask are:

1) "What is the target muscle of the exercise?"

2) "Which joint / articulation is moving, or moving MOST?"

3) "Does the target muscle cross that joint?" "Does it produce that motion?"

The <u>target</u> muscle should be producing the movement - not simply holding tension.

It should only be the <u>non-target</u> muscles that are working isometrically.

As one final example of this type of "error", we sometimes see someone in the gym attempting to perform a ***Cable Triceps Pushdown****,* with the intention of working their Triceps muscle. However, (in this example) because they are unaware of how to do the exercise correctly, they move their shoulder joint, while keeping their elbow mostly straight (illustration below-left). Of course, the correct form is with the elbow bending, and the shoulder joint be held still (illustration below-right).

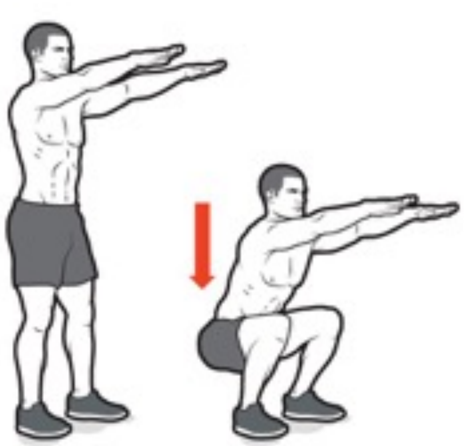
(Note: Most veteran "lifters" know the difference between someone performing an incorrect Triceps Pushdown, versus a "Straight Arm Pulldown".)

Performing a *Triceps Pushdown* with this kind of improper form, still engages the Triceps muscle, **but only isometrically**. The Triceps is keeping the elbow in a rigid position, by way of static tension. Meanwhile, the muscles that cross the shoulder joint -

the Latissimus, the Posterior Deltoids, the Teres major - are the ones that are producing the downward movement, by bending ("adducting") at the shoulder joint.

The **reason** this would be considered "incorrect" form (as a Triceps exercise) is because tensing the Triceps Isometrically is NOT as productive as utilizing the Triceps Dynamically.

The reason we perform "Dynamic" squats (with movement), is because they develop the Quads and Glutes better than Static squats against a wall.



The reason we perform *Supine Dumbbell Presses* (with movement), is because they develop the Pectorals better than a *Static Push-Up*.

Torso Rotations, performed **with movement** - against an opposing resistance - is more productive than a Static torso hold, with resistance.

Side Bends, performed **with movement** - against an opposing resistance - is more productive than a *Static Side Plank*.

Ab crunches, performed **with movement**, against bodyweight or resistance provided by a cable - is more productive (for development of the Abs) than a static plank.

Dynamic muscle contraction is good. Static muscle contraction is compromised. It's better than no muscle contraction at all, but it's not as beneficial as Dynamic muscle contraction, for muscular development and improving functional strength.

The are only two exceptions to this rule - 1) if there is some type of injury or other physical anomaly that inhibits normal freedom of movement, and/or 2) if the goal is to maximize the strength of a muscle in one specific position. For example, a Boxer may want torso "rigidity" to allow better resilience to punches in the Ring.

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Range of Motion

Up to this point, our discussion has been on "movement" versus "no movement". We've concluded that exercise **with movement** (Dynamic) is generally <u>better</u> than exercise **without movement** (Static / Isometric).

This brings us to the question of "**how much** movement is necessary or enough?". It's easy to compare ***zero range of motion*** with ***full range of motion***. It's not so easy to establish an absolute rule about how much range of motion is ideal.

Needless to say, we've all seen people in the gym foolishly doing exercises with an extremely abbreviated (short) range of motion. It's safe to say that <u>insufficient</u> range of motion will compromise the benefit of an exercise. 10% range of motion is almost worthless. But is 100% range of motion absolutely **necessary** - or even "**best**"? Is 100% range of motion always **safe**? Is 80% as effective as 100%? At what point is it **insufficient**?

A muscle's "full" range of motion can be defined as being from the point at which the muscle is most elongated, to the point where it is most shortened. However, using "full" range of motion is actually **not** necessary for optimal muscular development - and often has potential consequences. So, if 100% is not necessary, then how much is "enough"? It depends on a number of variables, which include the following:

1. The resistance curve of a specific exercise

2. Whether a muscle / joint has the potential for experiencing "Mechanical Disadvantage"

3. The amount of weight used in a given exercise (represented as a percentage of maximum effort for that muscle).

4. The limitations of the joint being operated by the target muscle

5. Whether or not the muscle has been warmed up

In Chapter 3, we discussed the Mechanical Disadvantage that occurs when the Biceps is pulling on the forearm from a parallel angle (when the elbow is straight). As such, it would be risky to perform a full range of motion (full extension) on a *Preacher Barbell Curl* (below-left), while using a weight that represents anything more than about 50% of the Biceps' maximum effort. The combination of Mechanical Disadvantage, with a Resistance Curve that provides too much resistance at the beginning of the movement, and using a significant amount of weight, could jeopardize the safety of the Biceps tendon.

However, It would **not** be risky to perform a full range Biceps extension when performing a *Standing Barbell Curl* (above-right), because when the forearm is parallel to resistance (at the beginning of the range of motion), there is no load on the Biceps - so the Mechanical Disadvantage that occurs there would be almost irrelevant.

It would also not be risky to perform a full extension on a Preacher Barbell Curl if the weight being used is relatively light. So, a combination of factors could influence the "appropriate" range of motion of an exercise.

This subject is complex and is subject to numerous conditions. However, basic "Range of Motion" guidelines should be established here, since this chapter deals with "Dynamic Muscle Contraction", and that implies range of motion.

1. We know that skeletal muscles have more strength potential when they are elongated, versus when they're shortened / contracted. Therefore, it's safe to assume that the early part of the range of motion, is more productive than the latter part of the range of motion. So, as a rule, we could say the if one is going to abbreviate part of the range of motion of an exercise, it's better to abbreviate the second half of the range of motion, rather than the first half of the range of motion. "Early Phase Loading" requires the first half of the range of motion - arguably, the first 30%.

2. We know that there can be some degree of increased injury risk at the maximum stretch position of a muscle, especially if the weight being used is "very heavy" (allowing fewer than 6 repetitions, generally). This may be exacerbated if there is also an unusual Mechanical Disadvantage occurring at that point. So, as a rule, we could say to "be careful" during, or simply omit, the most elongated 10% of the range of motion, of exercises that load heavily in the early phase. The exception to this would be when the weight being used is VERY light, and the focus is more on actual stretch of the muscle, than on loading a muscle.

3. The **final** 10% of a muscle's range of motion - the part that takes it to a maximum contraction - seems to be the least "productive", from the perspective of hypertrophy (growth). Also, there does seem to be a bit more risk - especially in the joints that extend, like the elbow (Triceps extension) and the knees (Quadriceps / Leg Extensions). So, be careful there, or abbreviate that part.

4. This leaves the middle 80% of the range of motion. That is likely the most productive and the most safe - with the first 30% of that range, being the most critically important.

5. During the early part of a set - when the muscle is least fatigued, and is capable of performing 80% range of motion - it is good to use as much range as possible, assuming it's within one's comfort range (no pain or discomfort). However, as the muscle becomes more and more fatigue, and less capable of that much range of motion, it's "acceptable" to lessen the range of motion to whatever is necessary - even if it's only 50% movement. But this should be determined **only** by necessity - not by "laziness". It should be determined by a greatly diminished physical ability (fatigue to the point of failure) - not by lack of willingness. Lessen the range of motion, only when you must - if the only other alternative to stop completely.

6. Never use so much range of motion that it **distorts a joint** to a painful degree, or takes a limb significantly beyond "normal" ranges, or contorts the body into extremely "unnatural" positions. Extreme stretch - as part of the range of motion of an exercise - has never been associated with greatly enhanced muscle growth. In the extreme stretch position, there is a drastically reduced potential benefit, and a drastically increased risk of injury.

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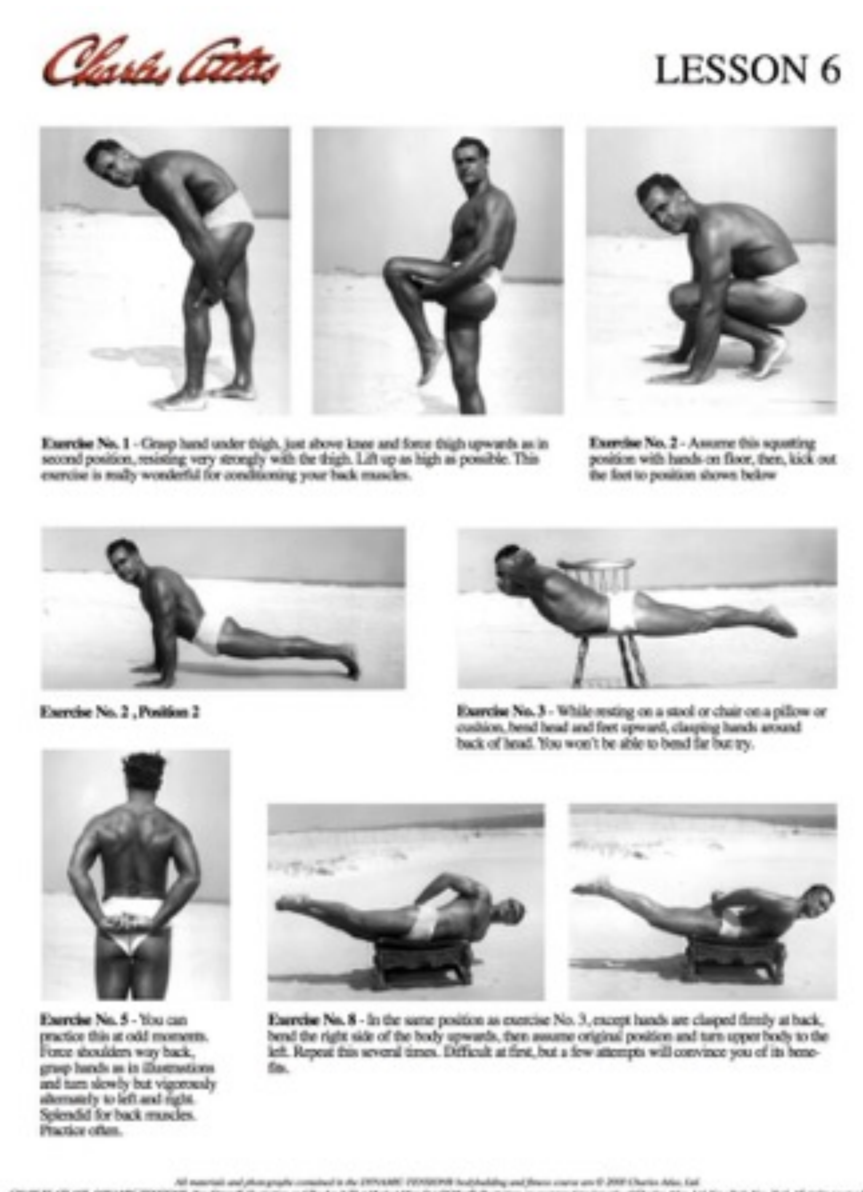
A Bit of History Re: Isometric Exercise

In the early 1920s, a man calling himself "Charles Atlas" (real name: Angelo Siciliano) began promoting an exercise program called ***"Dynamic Tension"*** - which was based entirely on Isometric Exercise. The irony here is that he called his course "Dynamic", but, in actuality, it was the **opposite** of Dynamic Exercise. It was Static Exercise.

In the course he marketed, a person would perform a series of exercises - all **without** weights and without movement. The exercises were all static holds, whereby a person would simply hold a tense position, press or pull against immovable objects, or their own opposing force.

His advertisements became iconic - a cartoon showing a scrawny man on the beach, bullied by a larger, more muscular man - embarrassing him in front of his girlfriend. The scrawny man then buys the ***“Dynamic Tension”*** course, and - after a short while (“in only 15 minutes a day”) - he miraculously transforms himself into a muscular He-Man. He returns to the beach and punches the bully in the face - thereby winning the admiration of his girlfriend.

In his advertisements, Charles Atlas publicly claimed that he had developed his physique using this same static tension exercise course. He became the poster boy for **isometrics**, of that era. Yet, he actually developed his physique by performing traditional weight lifting exercises.


Charles Atlas

LESSON 6

Exercise No. 1 - Grasp hand under thigh, just above knee and force thigh upwards as in second position, resisting very strongly with the thigh. Lift up as high as possible. This exercise is really wonderful for conditioning your back muscles.

Exercise No. 2 - Assume this squatting position with hands on floor, then, kick out the feet to position shown below

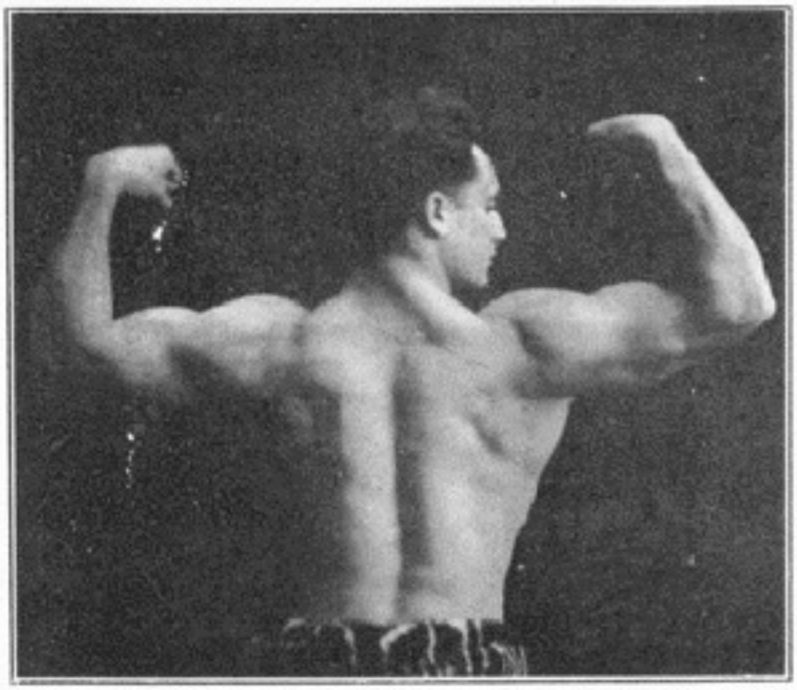
Exercise No. 2 , Position 2

Exercise No. 3 - While resting on a stool or chair on a pillow or cushion, bend head and feet upward, clasping hands around back of head. You won't be able to bend far but try.

Exercise No. 5 - You can practice this at odd moments. Force shoulders way back, grasp hands as in illustrations and turn slowly but vigorously alternately to left and right. Splendid for back muscles. Practice often.

Exercise No. 8 - In the same position as exercise No. 3, except hands are clasped firmly at back, bend the right side of the body upwards, then assume original position and turn upper body to the left. Repeat this several times. Difficult at first, but a few attempts will convince you of its benefits.

In a 1918 edition of a “Liederman” booklet, it states that Atlas performed a one-arm overhead press with a **236 pound weight**. A separate 1920 edition states that he did a one-arm press with a 266 pound weight. He clearly trained and developed his physique using weights - **Dynamically** (with movement).



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CHAS. ATLAS

(Address given upon request)

Mr. Atlas, I am proud to say, is another example of what correct exercise will do. He is my strongest pupil and what I have done for him I can do for anyone if they will follow my progressive system as he has done.

This photo was taken immediately after completing my course, and you cannot judge his size by this picture.

Mr. Atlas recently pressed 236 lbs. over head with one arm, and I predict he will shortly rank with the world's best. He has a 17¼ inch neck, a 16½ inch biceps, and a 48½ inch chest.

[Page Thirteen]

Of course, he realized the marketing appeal of selling a course that “*anyone could do, without any equipment, in the comfort of their own home*”. The exercises were easy to understand and easy to do, as compared with the more intimidating and more complicated, weight-lifting exercises. Apparently, by the early 1940s, he had sold over 400,000 copies - at $30 each. If those figures are correct, “Charles Atlas” and his business partner made over $12 million - which would have been an even more staggering amount of money in those days.

Obviously, very few people knew back then that Charles Atlas had actually **not** developed his physique using only the program he was selling. Today, this might be considered “false advertising”. There was no way of researching such things back then. But even today, there are many products that are marketed as “miraculous”, but could not possibly produce the results the manufacturers claim.

In fairness, Charles Atlas was a dedicated fitness practitioner and exercised diligently his entire life. Even at the age of 75, he was known to do his daily morning exercise routine included 50 knee bends, 100 sit-ups and 300 push-ups (none of which are “Isometric”, by the way). He was also a devoted husband and father. However, he was a business person, and he realized that many people wanted to be strong and muscular, and were willing to pay a price for that.

Today’s fitness industry is perhaps more commercially driven than ever. There will never be a shortage of people willing to sell a program that cannot possibly deliver the results promised, nor will there ever be a shortage of people willing to buy a “fantastic claim”, without evidence that it works.

Ideally, whether we're students or teachers of exercise, we should KNOW which exercises have more benefit, and which ones have less benefit - which ones have more risk and less risk. We should not believe, nor create the false impression, that all exercises are equal, and therefore they're all interchangeable.

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Summary

For purposes of physique development, visible muscle growth, strength gains through a muscle's entire range of motion and improved mobility, Dynamic resistance exercise is better than Static (Isometric) resistance exercise.

Using a longer range of motion when performing resistance exercise, is more effective for increasing muscle size and strength, as compared with using a shorter range of motion.

A study published in the "**Journal of Strength & Conditioning Research**" (January 2014 - Volume 28 - Issue 1 - p 245-255) concluded that increases of muscular size and of muscular strength was greatest in a test group that used the longest range of motion (the exercise tested was the Squat). This was true even though the group using the shorter range of motion used 10% to 25% more weight (resistance), than the group using the longer range of motion.

When evaluating a **Static** exercise - like the Plank - one needs to consider the energy cost / benefit ratio of that exercise, as compared with Dynamic exercise options.

For example, the Plank causes isometric contraction of the Rectus abdominis, the Quadriceps and the hip flexors (primarily). So, one might surmise that there are three muscle groups working at the same time, and think that this is "good" because it saves time. However, one of those three muscles (the hip flexors) are generally not a muscle requiring much exercise, and the other two muscles (the Abs and the Quads) can be worked much more effectively (better visible and functional results) with Dynamic exercises.

Many exercises require that certain muscles to provide **stabilization** by way of Isometric contraction, while the target muscle works dynamically. It's important to do this "correctly", knowing that the muscles working **Dynamically** will benefit more than the ones working **Isometrically**.

The stabilizing muscles are meant to **hold still** their corresponding joints still, while the muscles we intend to target should be **producing movement** in their corresponding joints.

Chapter Ten

The "All or Nothing" Principle of Muscle Contraction

& the Myth of "Shaping" a Muscle

When a muscle fiber contracts, it does so from origin to insertion.

It is impossible for only part of a muscle fiber to contract, or for one end of the muscle fiber to contract more than the other end.

Either the entire length of the muscle fiber contracts evenly, or it does not contract at all.

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Like so many human endeavors, bodybuilding is filled with folklore - beliefs that are based more on wishful thinking, than on fact or logic. People often believe that certain exercises will change the shape of a muscle (beyond simply making it larger), in ways that would make it more aesthetically pleasing. Unfortunately, it's physiologically impossible*.

It is common for people to assume that someone with an amazing physique, developed that body with some special insight. We assume that every exercise that person does, is 100% effective, and that that person had full control over the shape his body has taken. This is a false assumption.

This is not to suggest that the person with an amazing physique hasn't worked hard. It's just that when a person does ten different exercises for each physique muscle, it's impossible for the average person to know which exercises contribute more, and which contributed less. They did NOT all contribute equally - that is an absolute fact. But most importantly, the shape of the physique we end up with is mostly pre-determined by genetics.

Certainly, we can make a muscle larger. But the genetically determined **shape** of that muscle will then simply be a larger version of what it was when it was smaller. One analogy I've heard, with which I agree, is that a circle is still a circle, even when it's bigger. It doesn't become a rectangle. So it is with muscles.

(Note: There are only two muscles which could be regarded as "exceptions" to the rule, and that is only because their fibers travel in such divergent directions. These are the Pectorals and the Trapezius. We can direct movement and resistance toward one group of fibers, or another group of fibers. However, the "all or nothing" rule still applies the fiber contraction. When a muscle fiber contracts, it does so from origin to insertion, or not at all.)

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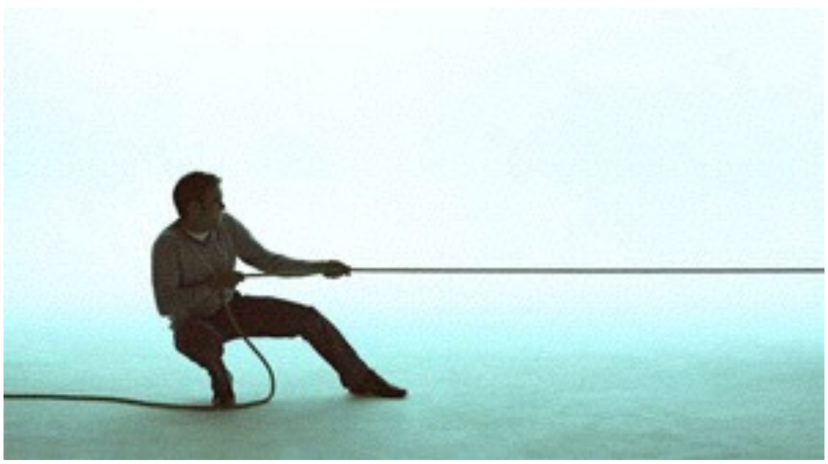
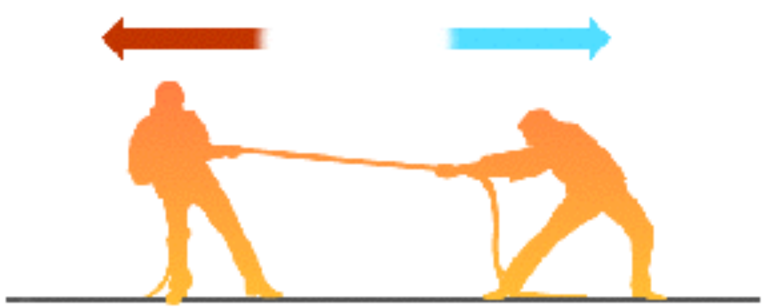
Muscles are similar to ropes or elastic bands. Let's say you tie a rope around a tree, and pull on it (below). Notice that the rope is evenly taught? It is not more slack, nor more taught, anywhere between you and the tree. The tension is evenly distributed along the entire length of the rope. Muscles operate the same way.



Let's see what happens during a "tug-of-war", where **both** ends are free to move.



If the man on the right (above) were “winning”, would the rope be more taught closest to him? No, it would not. It does not matter who’s “winning”. It does not matter whether the rope is moving more to the left or to the right. Either way, the rope will have **even tension** throughout.

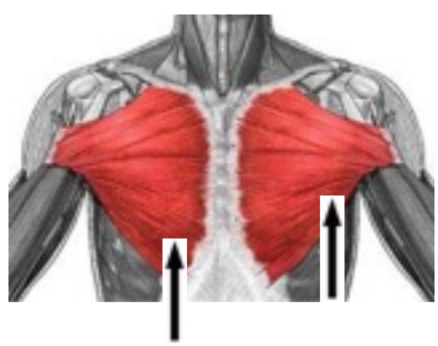
It’s all or nothing. Either the entire length of the rope has tension, or there is no tension anywhere on the rope. It is impossible to pull on the rope in any way, such that more tension is on one end, and less tension is on the other end. If the amount of force increases, it increases everywhere on the rope. If it decreases, it does so evenly throughout the entire the length of the rope.

The same is true with muscles. Whatever muscle force is required to produce the lift, will be evenly distributed through the entire length of the muscle, from the origin (where it begins) to the insertion (where it connects). A muscle would be **unable to produce skeletal movement**, if the tension along the muscle fiber was not evenly taught, from origin to insertion.

Let’s look at some examples, and see how this works in the human body.

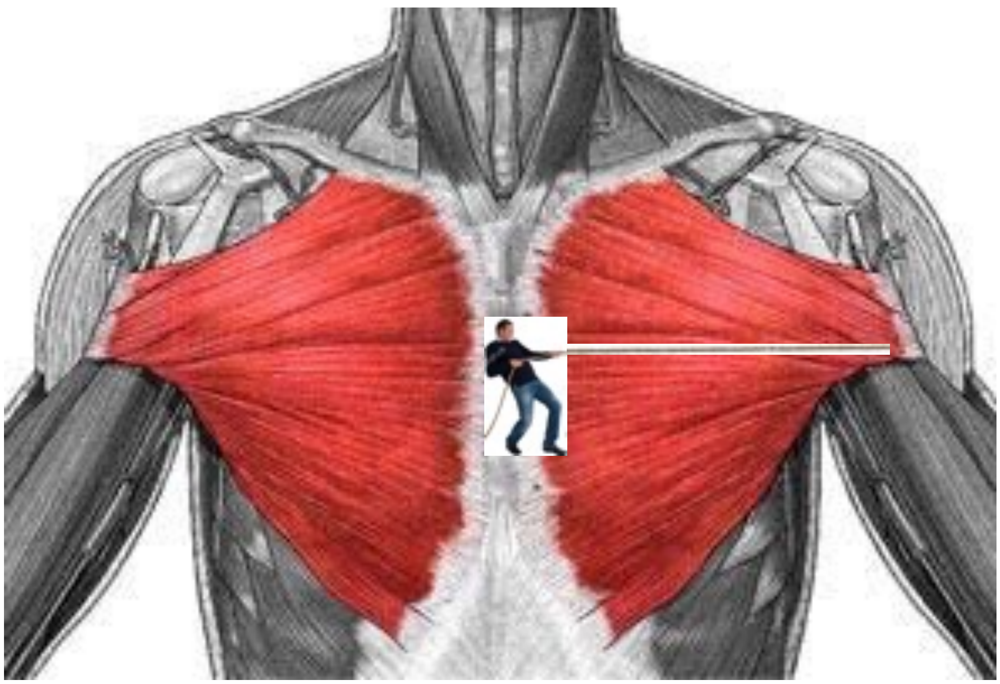
“Inner” and “Outer” Pectorals ?

For years, some have thought that a Supine Dumbbell **<u>Press</u>** works the “inner” portion of the pecs (photos below-left) - whereas a Supine Dumbbell **<u>Flye</u>** works the outer part of the Pecs (photos below-right). This is completely FALSE.



As you can see below, the (Sternal) Pectoral fibers run from the sternum to the humerus, in one continuous “rope”. When the muscle contracts, it pulls the humerus TOWARD the sternum - regardless of whether the elbow is more bent or less bent. In other words, the **humerus** is doing the exact same thing in both cases, and so is the Pectoral muscle.

The only difference between the two versions above, is the “effective length of the lever” (i.e., the arm). A longer “effective” lever (illustration above-right) magnifies resistance more, so requires that less weight be used. But either way, the Pectoral fibers that are working, contract from origin to insertion.



There’s simply no way for the “rope” (i.e., the muscle fiber) to contract more on one end, than the other end. The only way for the muscle to do its job (which is skeletal movement) is for the muscle fiber to be evenly taught throughout, while it pulls the humerus (arm) toward the sternum.

“Upper Abs” and “Lower Abs” ?

This is one of the most common examples of not understanding the “All or Nothing” Principle of Muscle Contraction.

We often hear people talk about the “lower abs”. If you were to do an internet search on “lower abs”, you’ll find MILLIONS of articles making recommendations for “how to work the lower abs”. **Yet, there is no such thing as “lower abs”**. It doesn’t exist.

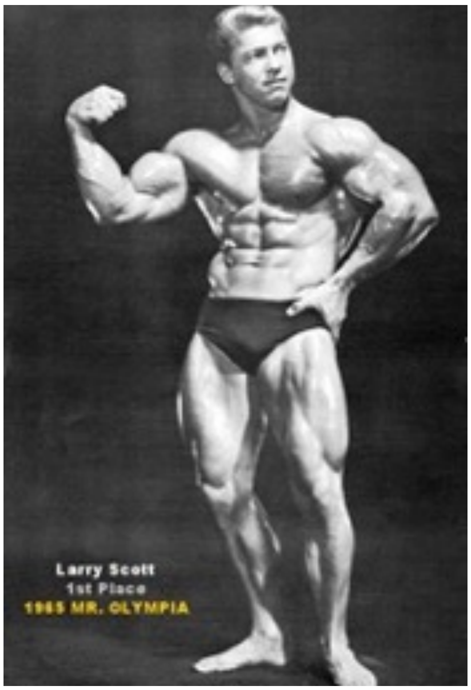
Below, we see a side view of the Rectus abdominis. It is a single sheet of muscle, that originates on the ribs and attaches to the pubic bone of the pelvis. When the muscle contracts, it pulls the front of the ribs **toward** the pelvis - or the pelvis toward the ribs - but either way, the muscle contracts the same. The muscle doesn’t “know” which end is moving toward which end. This is analogous to the Tug-of-War mentioned above. It doesn’t matter who is “winning” the Tug-of-War. Either way, the rope is evenly taught throughout.

Yes, you could “point” to the lower region of the Rectus abdominis - just like you could point to the inner part of the Pectorals, or the outer part of the Pectorals. But causing that “part” of the muscle to contract more than any other “part” is **impossible**. It would defeat the purpose of muscle contraction: “to pull the origin and the insertion toward each other”.

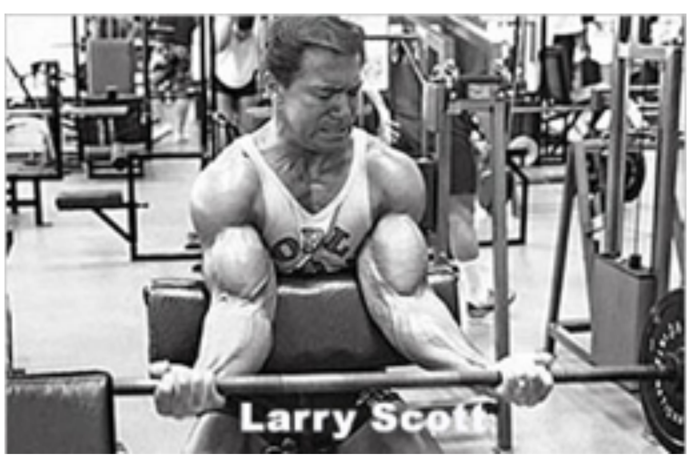
So, when we work our abdominal muscles, the entire muscle contracts - from origin to insertion. It is impossible to work the “upper abs”, and it is equally impossible to work the “lower abs”. The entire muscle contracts, or none of it contracts - “all or nothing”.

Making Biceps More “Full”?

In the 1960s, a man named Larry Scott dominated the bodybuilding scene. He won Mr. California in 1960, Mr. America in 1962, Mr. Universe in 1964. He won Mr. Olympia in 1965 and then again in 1966. Although he had an excellent overall physique, he was especially known for his arms - his biceps, in particular. They were big, of course. But they were also unusually "full". By this, we mean that his biceps went all the way into his elbow, whereas most biceps stop about a half an inch before the crook of the arm.



People assumed that Mr. Scott MUST be doing some special exercise, to cause his Biceps to be so full. Interestingly, he did have a "favorite" exercise - which was known as the "Preacher Curl" (photo below). Many people, therefore, believed that this particular exercise was responsible for the shape (i.e., the fullness) of his biceps. Thus, the exercise became known as "Scott Curls".



The fact is that Larry Scott's Biceps were shaped exactly as his genetics had predetermined. Regardless of which exercises he had chosen to do, his Biceps would have had the exact same shape, notwithstanding fluctuations in overall size.

Of course, some people might say, "how do you know what Larry Scott's Biceps would have looked like if he had NOT done those curls?". Very simply, it has never been duplicated, despite thousands of people - if not millions - having done the exact same exercise. No one has ever developed arms like that of Larry Scott's.

But that is not the only reason we can be assured that it was not "Preacher Curls" that produced those arms. From the perspective of physics, there is simply no way that the any part of a continuous muscle fiber, anywhere between its origin and its insertion, can be make to experience more tension that the rest of the fiber.

It's true that Preacher Curls have a resistance curve that is different than that of the Standing Barbell Curl. Preacher Curls cause the Biceps to experience more resistance at the beginning of the range of motion (when the elbow is extended, and the arms nearly straight), than does the Standing Barbell Curl. However, this does not influence the shape of the Biceps. It simply starts the resistance sooner (in the range of motion) and diminishes it sooner.

Did Mr. Scott believe "Preacher Curls" influenced the shape of his Biceps? Unless he was familiar with physics of bio-mechanics, he probably did believe that. However, he might have also been aware of how many others used that exercise, trying to get the same result, and failed. That would have been the first clue that "it's not the exercise" that created those arms.

However, Mr. Scott DID try to convince people that this exercise could make anyone's Biceps more "full" (longer). After all, people were willing to pay him money for the secret to his extraordinarily "full" Biceps. And, just like Charles Atlas in the previous chapter, business isn't always about getting the truth. Fitness has a long history of "snake oil" and unsubstantiated claims - even if a marketer in sincere in their incorrect recommendation.

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The Myth of Muscle Shaping

Normally, when we speak of the "**All or Nothing Principle of Muscle Contraction**", we are referring to "ends" of a muscle fiber - the fact that the entire **length** of a fiber contracts, if it contracts at all. However, the "all or nothing" principle also applies in regard to muscle **groups** which perform a single function in unison.

The Biceps is comprised of two “heads” - both of which produce the same primary function: elbow flexion.

The Triceps is comprised of three “heads” - all of which produce the same primary function: elbow extension.

The Quadriceps is comprised of four “heads” - all of which produce the same primary function: knee extension.

The Calf muscle is comprised of two “heads” - both of which produce the same primary function: plantar flexion.

People have long believed that these muscles can be “shaped” - that is to have one “head” (part) of the muscle emphasized more during a particular exercise, than the other part(s). However, because the function of these groups of muscles is **singular ***, it’s physiologically impossible.

This will be further discussed in the Anatomy section of this book - body part by body part. The muscles mentioned above operate on an “all or nothing” basis. When each of those muscles perform their respective functions, the entire muscle (all parts of it) participate in the movement, in unison.

(Note: The muscles mentioned above - with the possible exception of the Calves - do have at least one other function in which they assist. This does not negate the fact that these muscles DO have a “primary” function - and that is the function that best contributes to hypertrophy. The “assist” function of these muscles is not primary enough to cause significant hypertrophy in that particular muscle.)*

Our genetics determines the general shape of our muscles.

If our Triceps are “short” - meaning that they do not sweep all the way down to our elbow - there is no exercise that can cause the muscle to change its genetically determined shape.

If our Lats are “high” - meaning that they do not sweep all the way down to our waist - there is no exercise that will cause the Lats to change the form by which they attach to the spine and pelvis.

If your Quadriceps have a “boxy” appearance, and you prefer a more graceful “sweep” - there is no exercise you can do which will produce that change. When the Quadriceps work, they do so in the one-and-only manner they can, regardless of the exercise that is causing their activation.

There are only two exception to this, but even these exceptions have limitations.

When we work the Pectorals, we can select a **direction of anatomical movement** (of the humerus) - with a directly opposing resistance, of course. We can move our arms more toward the sternum (for the Sternal fibers); we can move our arms more toward the ribs (for the Costal fibers); and we can move our arms more toward the clavicle (for the Clavicular fibers). This will be discussed further in the Pectoral section of this book.

When we work the Trapezius, we can select a **direction of anatomical movement** (of the scapula) - with a directly opposing resistance, of course. We can move our scapula straight upward (for the Upper Trapezius fibers), or we can move our scapula backward (for the middle and lower Trapezius fibers).

All other muscles typically move their corresponding lever / limb in one primary direction. This not only hints at the fact that that particular muscle cannot be "shaped" according to one's wishes. It also suggests that there is one "best" movement for that muscle, and that should be the one that is most used for the development of that muscle.

This will be further discussed in the Anatomy section.

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Summary

As with any endeavor in which there is a tremendous amount of passion, myth and folklore have lead us to believe that there are "secret" exercises which can produce the exact muscle shape we desire. Unfortunately, there is no truth nor science behind these beliefs.

Weight lifting, bodybuilding, calisthenics - all have their passionate followers. Each of these have their pseudo experts, who claim to have an understanding of that field beyond that of others. In most cases, these "leaders" have demonstrated their own prowess within that field in some way. This contributes to their confidence and credibility - even if that prowess is more due to genetics, than to actual insight.

This is not to suggest that these leaders, "experts" and champions of the past have not worked hard, have made a sincere effort to gain as much knowledge as they could, nor have made an positive contributions to their respective fields. They deserve their due, to be sure. However, many of their teachings and recommendations are simply incorrect. This can easily be demonstrated using bio-mechanical analysis.

A muscle that contracts against an opposing resistance, does so from origin to insertion. It is not possible to preferentially contract one end of a muscle, more than the other end of a muscle.

There is no “Lower Ab” muscle - not as a separate muscle, nor as a section which can be preferentially isolated.

A muscle’s shape is genetically determined. It cannot be influence or altered with different exercises.

Chapter Eleven

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Reciprocal Innervation

& Workout Structure Strategy

Human skeletal muscles are arranged in antagonistic pairs, which produce a contractile force in opposite directions. These are referred to as "agonist / antagonist" muscles.

Our central nervous system is designed to <u>inhibit</u> the contraction of an antagonist muscle, while the contraction of an agonist muscle is occurring. For example, it's impossible to contract the Biceps, while simultaneously contracting the Triceps.

This inhibition is called "reciprocal innervation". The contraction of an agonist muscle results in a simultaneous and commensurate <u>relaxation</u> of the corresponding antagonist muscle(s), so as to prevent self-defeating efforts.

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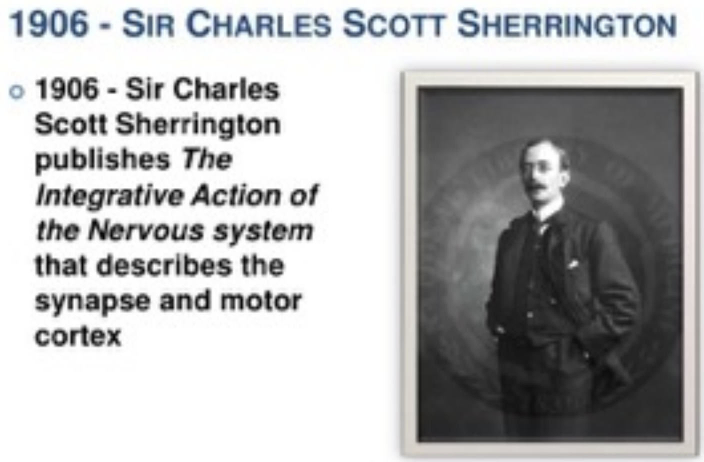
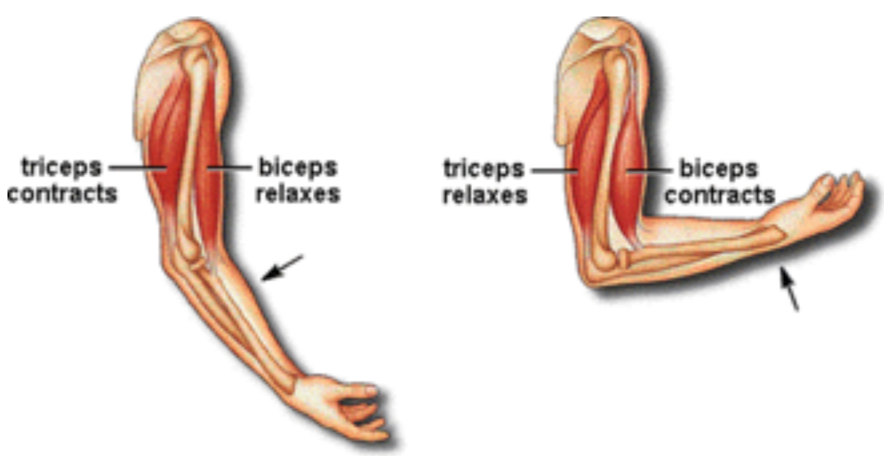
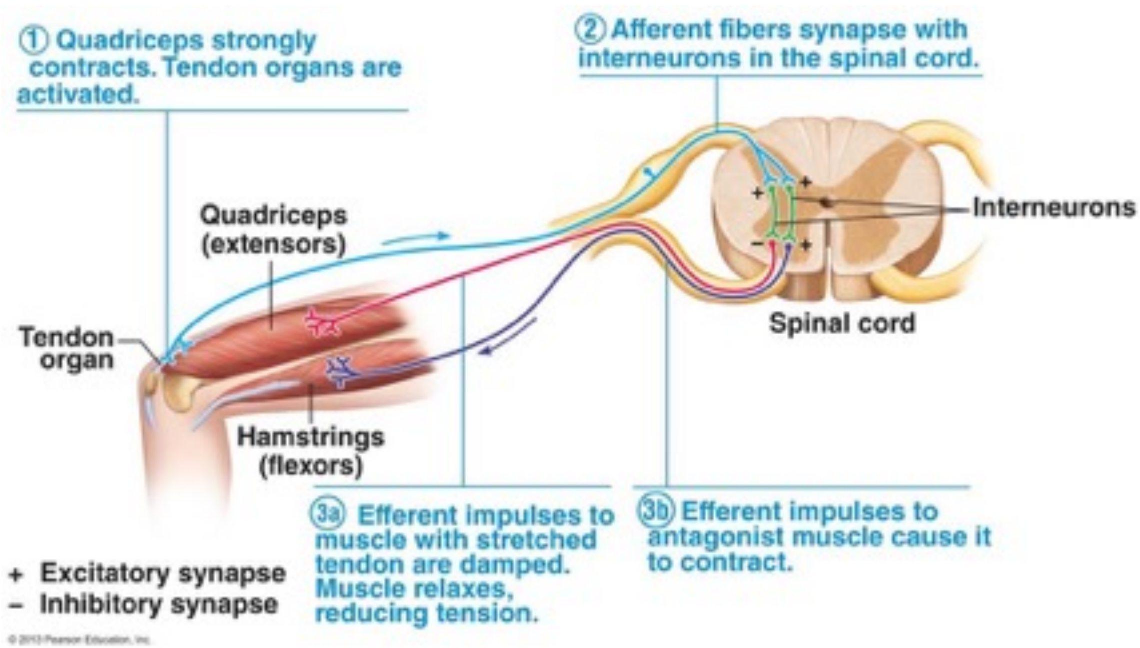
French philosopher, mathematician and scientist - Rene Descartes (1596 - 1650) - was the first to hypothesize "**reciprocal innervation**" in 1626.

Later, Charles Scott Sherrington (1857 - 1952) - English neurophysiologist, bacteriologist, pathologist and Nobel laureate - established “Sherrington’s Law of Reciprocal Innervation” (also known as “Sherrington’s Law II”), which explains how a muscle relaxes when its opposing muscle is activated.



Here’s how it works. You walk over to a table and pick up a box. As you hold the box (with elbows bent), your Biceps are activated by the downward pull of gravity on the box. This sends an immediate signal to the brain, by way of the spinal cord, which instantly **inhibits** an opposing contraction of the Triceps, by way of an “inhibitory synapse”. This is nature’s way of preventing any interference which would be caused by the opposing muscle, if it were to contract at the same time. One cannot push **and** pull, at the same time, with a same limb.





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In Chapter 4 ("The Apex and the Base"), we talked about what happens when a person performs an exercise, during which their operating lever crosses over to the other side of the Apex or Base. The load transfers to whichever muscle is on the **opposite** side of that "limb". That causes the second muscle to become loaded, and the first muscle to "shut off" - due to "**Reciprocal Innervation**".

Specifically, we talked about the ***Triceps Kickback*** exercise. When the forearm crosses over to the other side of the Base (toward the shoulder), it activates the Biceps. This activation of the Biceps automatically **relaxes** (inhibits) the Triceps - which drastically reduces the effectiveness of that movement, as a Triceps exercise.

In the photo below-**left**, we see this person's left forearm has come down past the vertical position (moving toward her shoulder), after returning from the Triceps contraction. This crossing over activates the Biceps (for half its range of motion), but also causes the Triceps to **de-activate**. Of course, even if this person stopped the eccentric Triceps motion when her forearm was vertical (at the Base), the Triceps would still ONLY be getting half its normal range of motion. This demonstrates why the "Kickback" is not a "good" Triceps exercise - but also demonstrates the principle of Reciprocal Innervation.

Here are the agonist / antagonist muscle of the body:

Biceps	Triceps
Pectorals	Middle Trapezius / Posterior Deltoids
Upper Trapezius	Lower Trapezius
Abdominals	Lower Back / Erector Spinae
Quadriceps	Hamstrings
Calves	Tibialis Anterior
Forearm Flexors	Forearm Extensors
Quadriceps	Hamstrings
Left Obliques	Right Obliques
Gluteus Maximus	Hip Flexors
Lateral Deltoids	Latissimus Dorsi
Internal Shoulder Rotators	External Shoulder Rotators

All of the muscle combinations listed above, produce opposite direction movements.

The "agonist" is the muscle being activated at the moment - the antagonist is the muscle which would oppose the movement, or move that limb in the opposite direction. Each muscle assumes the opposite role, whenever the opposing muscle is activated. When one is activated (loaded / contracting) the other is relaxing.

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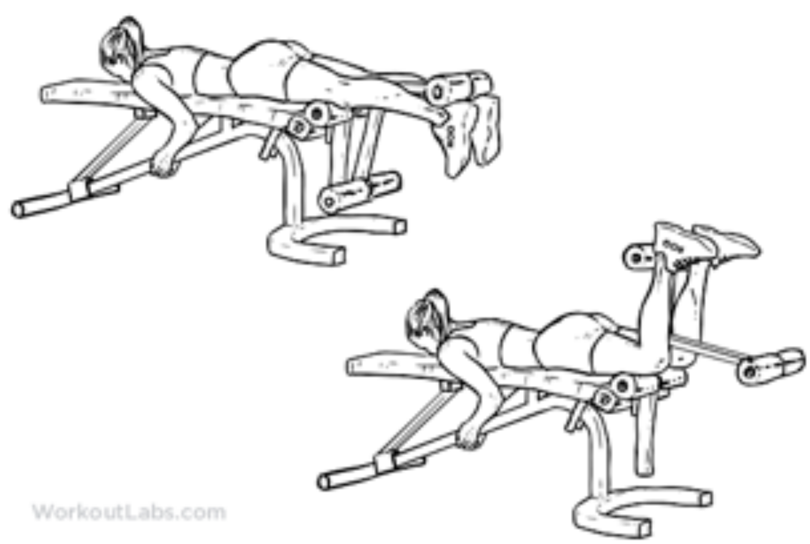
Knowledge of this principle allows us to select exercises more wisely, and it also allows us to be more strategic in structuring our workouts. In other words, use of this principle allows us to understand which muscle groups are better combined, in a given workout.

However, before we discuss the ideal workout structure, let's focus our attention on a **type** of Reciprocal Innervation that is often overlooked, but which has significant consequences.

We now know that **loading** a muscle causes the opposing muscle to shut off, or at least be "inhibited', to a degree. The question is this: "Is there a way of causing a muscle to be inhibited, OTHER than loading its opposing muscle?". The answer is "yes".

I would like to explain this by way of some history.

In the 60s, 70s and 80s, when we worked our Hamstrings, we did so on a machine like the one illustrated below. It was a FLAT Leg Curl machine (…usually a combination Leg Extension / Leg Curl machine - manufactured by "Universal Gym").



Most of us discovered that we had a tendency to raise our tailbones up, as we performed the Leg Curl.

By the late 80s, manufacturers began making "dedicated" ***Leg Curl*** machines (without the ***Leg Extension*** function), and with an **elevated** section under the hip - to compensate for the tendency of raising up the tailbone.

Raising the tailbone sometimes causes discomfort to the Lower Back. Some people have even considered this “tailbone lifting” as a type of “cheating”. Sometimes we even see TRAINERS pushing down on their client’s tailbone, to prevent it from lifting up.

We’ll soon see what causes this tendency, first-hand. Let’s conduct a little experiment, right now - right where you are.

While standing with your body weight on one leg (holding onto a chair for balance), do a “knee flexion” (Leg Curl) with the other leg. **AND, try to keep the femur of that leg well behind the femur of the leg on which you’re standing**.

What you’ll discover is that it’s rather difficult - even though you’re not using any added weight. You may even feel as though your hamstrings is cramping.

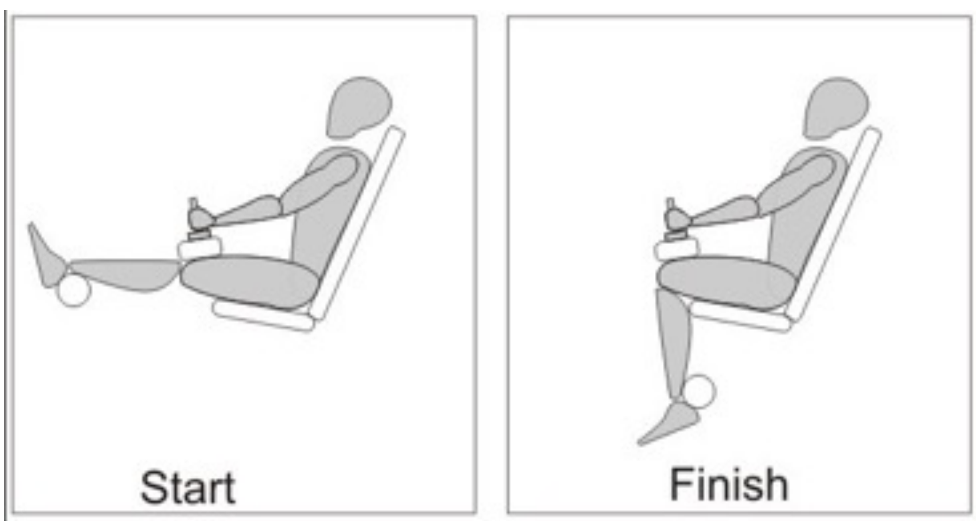
This is your central nervous system sending an inhibitory synapse to your Hamstring - trying to relax it - because your CNS is sensing “activation” in the Quadriceps.

You might now be thinking, "…but my Quadriceps is not **loaded**". That's right, it's not loaded. But it is **stretching**. If you were to bend your knee with a bend in your hip, you will not feel your Hamstring cramping, and this is because your Quadriceps are not stretching.

THAT is why we have a tendency to raise the tailbone when we perform Lying Leg Curls. The body is trying to relax (diminish the stretching of) the Quadriceps, so that the Hamstring is more free to contract without "interference" from the opposing side.

This demonstrates that the *Prone (Lying) Leg Curl* machine is a compromised way of working the Hamstrings. Using the ***Seated Leg Curl*** machine is a much better option, because it allows the hip joint to be bent at approximately 90 degrees to the torso.

You'll also find that using a ***Seated Leg Curl*** machine allows a better elongation (stretch) of the hamstrings, because of the hip angle.



Using a *Seated Leg Curl* machine requires a little more adjustment, as compared with a ***Lying Leg Curl*** machine. But, once you've made the correct adjustments for your individual **femur length** (i.e., the seat back), **tibia length** (i.e., the ankle pad / roller), **fulcrum point**, and preferred **range of motion**, you'll be doing the best exercise for the Hamstrings. You will have eliminated the conflict of Quadriceps interference.

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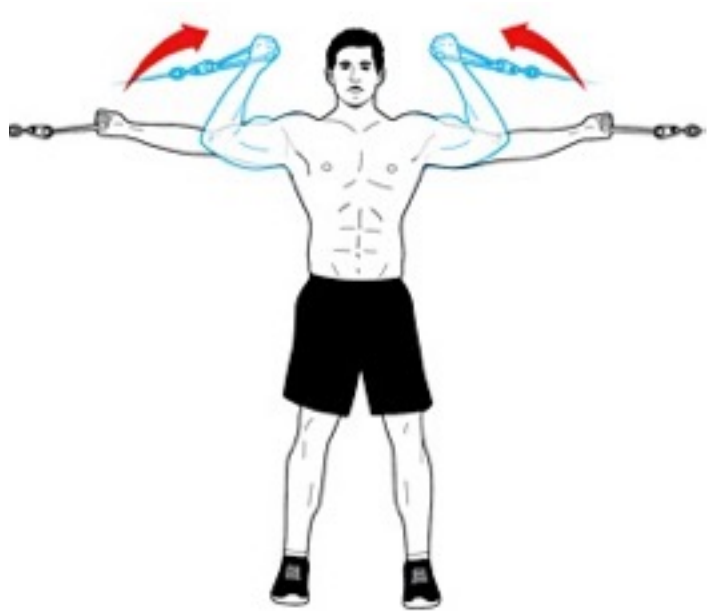
So, while Reciprocal Innervation rarely causes a problem during an exercise, due to "loading" both the agonist and antagonist muscles, the issue of **stretching** an antagonist muscle, while trying to work the agonist muscle, **does** occur more often.

For example, if we try to load / contract the Biceps, while simultaneously **stretching** the Triceps, we'll find that same awkward feeling in the Biceps - sometimes even cramping - that occurred in our Hamstring experiment above. Our CNS is trying to shut off the Biceps, because it sense activity in the Triceps. In order to have complete freedom to load / contract the Biceps (or any other muscle), we need to ensure that we are not inadvertently activating (neither loading nor stretching) the opposing muscle.

When we raise our arms up, and bend our elbows, we stretch our Triceps. Of course, the higher we raise our elbows, the more this occurs. But even a moderate elevation of the arms, can cause a Relaxation Synapse (Reciprocal Innervation) to occur in the antagonist muscle, thereby compromising the effectiveness of the agonist muscle.



In the exercise depicted above, there is a degree of Triceps stretching that occurs, with the arms elevated at this level (as the arms bend). This makes it difficult to fully engage the Biceps. If we were to do a similar exercise, but with the arms held even higher, it would be MORE difficult to fully engage the Biceps. You're very likely to feel that cramping sensation, just as we did in our Hamstrings.

Interestingly, most of the internet sites on which you'll find this exercise depicted, will say that this exercise helps develop the "peak" of your Biceps….and that this cramping feeling you experience in the Biceps while doing this, is "proof" of that. That's not correct. Instead, what you're feeling is a "conflict of interest" / shut-off message in the Biceps.

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Using Reciprocal Innervation to Structure Workouts

Because of the fact that relaxation occurs in a muscle when its opposing muscle is contracting, combining **opposing** muscles in a single workout is a good strategy. One could even do “super-sets” with those opposing muscles.

Alternating between two opposing muscles, takes advantage of the fact that while the agonist muscle is working (e.g., the Biceps), the antagonist muscle (e.g., the Triceps) is fully relaxing and recovering. Or, one can do all the sets of one body part (e.g., Pectorals), and then all the sets of the opposing body part (e.g., “Back” / Lats), in the same workout.

One of the most **common** muscle grouping practices - although not necessarily very wise - is known as “Push / Pull”. This is where the (so-called) “pushing muscles” are done on one day, and the (so-called) “pulling muscles” are done on a different day.

I say “so-called” because all muscles actually PULL. No muscles “push”. They contract by shortening - **pulling** the ends together - which then either flexes or extends a joint. Nevertheless, the “pushing muscles” are thought to be the Pecs and the Triceps, and the “pulling muscles” are thought to be the Back and the Biceps.

The rationale for this type of grouping is the belief that while the Pecs are working, the Triceps are assisting - and so one might as well “finish off” the Triceps at that time. Similarly, when the Back muscles (Lats, middle Traps, Teres major, etc.) are working, the Biceps are assisting - and so one might as well finish off the Biceps at that time.

However, if one performs the **better** Pectoral exercises, there would be very little Triceps participation. And if one performs **the better** “back” exercises, there would be very little Biceps participation.

If one **does** experience considerable Triceps and Biceps fatigue, while doing their Pectoral and “Back” workouts, it’s safe to say that those workouts have other mechanical problems that should be resolved, for maximum efficiency. One should NOT feel much Biceps and Triceps fatigue during highly efficient Chest and Back workouts. Never-mind the fact that it would better to work Biceps and Triceps when they’re fresh (not pre-fatigued).

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So, using “push / pull” as a guide makes sense - except not the way it is currently being used. Rather than separating “push” and “pull”, it makes more sense to **combine opposing** movements in the same workout.

Using "opposing movements" as the guideline for combining muscle groups would result in something like the following (not necessarily on separate days, but still combined):

1 Chest / Back

2 Front Deltoids / Rear Deltoids

3 Biceps / Triceps

4 Quadriceps / Hamstrings

5 Abdominals / Lower Back

6 Forearm Flexor / Forearm Extensor

(Note: Not all movements require an opposing exercise. For example, Calves do not automatically require that Tibialis anterior be worked, and Glutes do not automatically require that Hip Flexors be worked.)

Next, you decide whether you want to use a **two-way** split, a **three-way** split, or a **four-way** split. This assumes a person's goal is ambitious enough to want more muscle gain than can be achieved with a simple "full body workout" performed two or three times per week.

My personal preference is a four-way split program, which means four separate workouts with which to work the entire body. I like the four-way split because it allows me to complete each workout in a reasonable amount of time (approximately 1.5 hours), while still spending "enough" time (i.e., 6 to 12 sets) on each muscle group.

Splitting 12 to 15 muscle groups into four separate workouts, requires at least **five days per week** - ideally speaking. **Six days** per week is better. This provides each muscle with enough frequency, as well as enough recovery time.

Here's the typical workout structure I use:

Day One: Chest & Back (Pecs, Lats, middle Traps, Teres major)

Day Two: Shoulders (Deltoids - Lateral, Posterior and Anterior, and upper Trapezius)

Day Three: Arms, Forearms & Abs (Biceps, Triceps, Forearm Flexors, Forearm Extensors, Rectus abdominis, Obliques, Lower Back)

Day Four: Legs (Quadriceps, Hamstrings, Glutes, Adductors, Calves)

Here's is one way this could be scheduled, but several other variations could be created:

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Day 1	Day 2	Day 3	Day 4	Day 1	Day 2	
Day 3	Day 4	Day 1	Day 2	Day 3	Day 4	

This particular workout schedule would allow you to work each muscle group three times every two weeks - or one time every 4 or 5 days.

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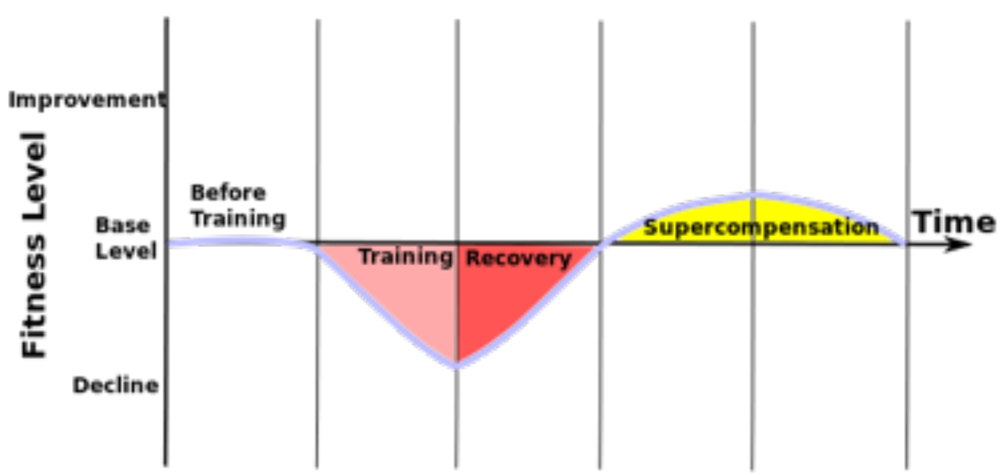
Intensity, Recovery & Adaptation

Since we're on the subject of how to structure one's workout, we might as well touch briefly on this subject. However, as mentioned before, this book is primarily intended as a **bio-mechanics** guide. Muscle **physiology** is another subject altogether. Nevertheless, we can review some basic points.

In general, a muscle needs a least two or three days of recovery after a workout - assuming a moderately high level of intensity is used. If one trains at higher levels of intensity, four or five may be required, before that muscle is worked again. The time between workouts for a given muscle is considered the "recovery" phase.

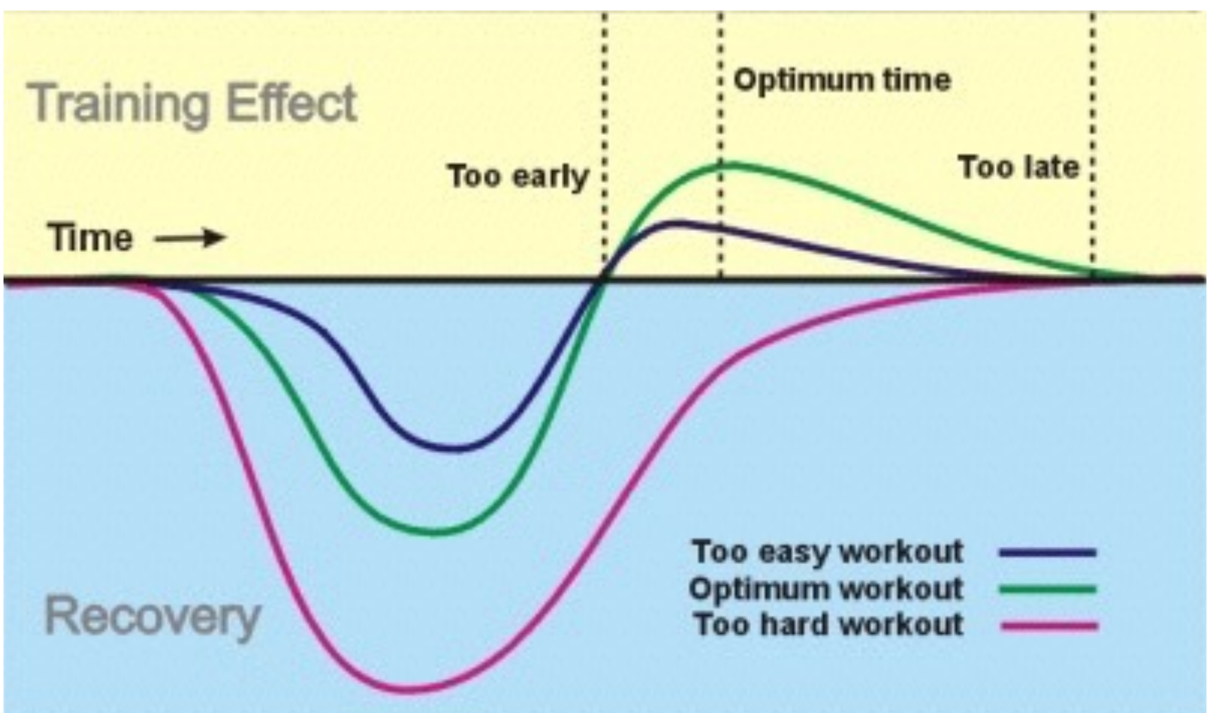
After the recovery phase, we transition into a phase called, **"supercompensation".** This is where the muscle has **adapted** to the stimulus from the previous workout, with a slightly higher performance capacity - in preparation for the next "bout".



Ideally, one should work a muscle again **while in** the "supercompensation" phase. This is important, because this phase is eventually fades, **along with the gains from the previous workout**. Within a relatively short period, the "slightly higher performance capacity" that was gained from the previous workout, returns to the baseline again. Working that muscle again, while it is in its "elevated" state, will send it up to a higher level. This is how "muscle accumulation" (growth) occurs. It builds on previous "highs" - like adding small amounts of sand to a pile, which eventually becomes a "hill". Conversely, waiting too long before one's next workout (after the "supercompensation" period has passed), would be like starting over again at the baseline.

Conversely, if the "next" workout (for that particular muscle) occurs **too soon** after the previous workout, "over-training" occurs. "Too soon" would be before the recovery phase is complete, so the muscle would not have had the chance to be fully recovered from the previous workout. Progress (muscle growth) for that muscle, would then be impeded.

Of course, the issue of exercise intensity factors in here. Using less workout intensity theoretically warrants **less** recovery time, and using more workout intensity theoretically warrants **more** recovery time - but only up to a point. There is such a thing as "ideal intensity" for optimal results (green line, below). Ideally, it should not be too low nor too high.



The belief (by some) that annihilating a muscle during a workout (leaving it absolutely limp with fatigue) will lead to maximum muscle gains, is not correct.

Recovery **<u>time</u>** is not necessarily the equalizer of the intensity level used. One cannot make up for **insufficient** workout intensity, simply by taking less time between workouts. Also, one cannot make up for **excessive** workout intensity, simply by taking an extra day or two of rest, between workouts. Too much exercise intensity results in muscle damage, from which one cannot easily recover. Yes - as we progress, our tolerance increases, and higher intensity is possible. But there is always a point of “too much.”

The most extreme form of muscle damage caused by **overly intense** exercise is called “Exertional Rhabdomyolysis”. When this occurs, the muscle severely breaks down. Its byproducts (which enter into the bloodstream) are harmful to the kidneys - possibly leading to kidney failure. Of course, this degree of “over-training” is extremely rare, especially in advanced athletes who are already highly trained. But it can still occur, even in advanced athletes.

There are several stages of over-training that occur before the onset of Exertional Rhabdomyolysis. In other words, one does not need to get to the extreme point, before overly-intense efforts have become counterproductive.

The “right amount” of workout intensity is required, and this varies from person to person, based on a number of factors. These include one’s individual health, enough sleep, sufficient caloric intake, adequate endocrine production, other daily activities (calorie demands) - and one’s current level of strength / endurance. Each person should experiment to find their own optimal level of workout intensity, and then balance that with exercise frequency.

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SUMMARY

Reciprocal Innervation is part of the amazing natural design of the human body.

Understanding the role it plays in Resistance Exercise allows a person opportunities to optimize muscle hypertrophy, but can also interfere with efficient workouts, if one is unaware.

It plays an important role in exercise selection, exercise productivity, exercise comfort and exercise program design (muscle grouping).

Virtually any kind of body part combining will produce results (muscle growth), including conventional “Push / Pull”.

I am not suggesting the using “Reciprocal Innervation” to organize your muscle groups into separate workouts is the “right way”, and all others are the “wrong way”. However, I do believe it’s a better way.

It makes good sense to set up one’s workout plan in a way that creates as little “conflict of interest” as possible. Meaning - it’s advantageous to work a muscle group without having any pre-exhaustion from a previous exercise. Using “Reciprocal Innervation” allows us to do that.

Chapter Twelve

"Compound" vs "Isolation"
The Origins of the Debate

* * *

There has been a pervasive belief, for decades if not centuries, that "compound" (multi-joint / multi-muscle) exercises are better than are "isolation" (single or duo joint) exercises, for nearly every goal.

As we'll see in the <u>following chapter</u>, bio-mechanical analysis proves this belief to be incorrect. Isolation exercises are actually better than are compound exercises, for many purposes.

The subject has been misunderstood. Even the distinction between the two types of exercise is much less clear than many assume (*this will be addressed in the next chapter*).

This chapter discusses <u>how we arrived at these erroneous beliefs</u>, and lays the foundation for a better understanding of these exercises.

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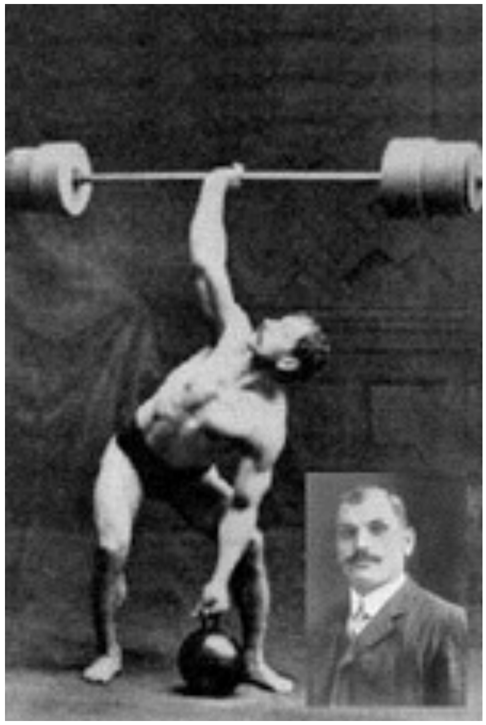
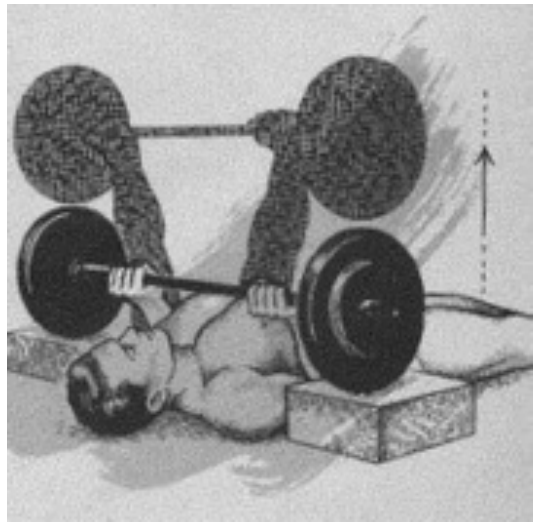
Physical strength has been revered since the origins of man. According to Greek legend, Herakles (aka "Hercules" in Roman literature) - theoretically born in the year **1276 B.C.** - was idolized for his "legendary" strength. Milo of Creton - a **6th century** wrestler - also was credited with many stories of amazing strength, including carrying a bull on his shoulders, every day, for exercise. By the **1800**s, "Feats of Strength" had become popular as entertainment and business.

Arthur Saxon (1878 - 1921) (shown below) was a "strongman" and circus entertainer. He became famous for performing a lift called "The Bent Press". It's a one-arm overhead lift, while bent sideways. He set a world record of 370 pounds.

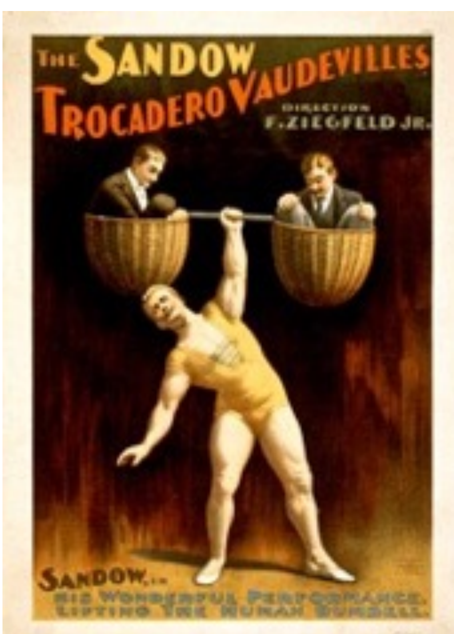


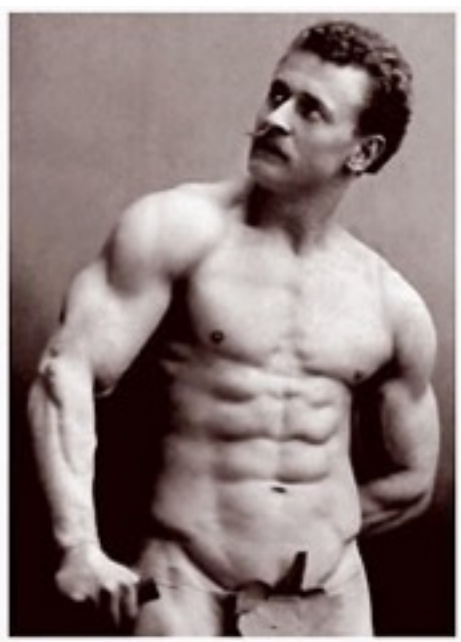
Louis Cyr (1863 - 1912) (shown below) performed a variety of strength “acts”, including lifting a horse off the ground, and holding a platform of 18 men, on his back.

George Hackenshmidt (1877 - 1968) was a professional wrestler and “strongman” (pictured below-left). In 1899, at the age of 18, he performed a “Floor Press” with 361 pounds. In this lift (illustrated below-right), the barbell is suspended a short distance off the floor by two wooden blocks, providing just enough room for a person to slide under the bar. The press is then performed. Clearly, this was the beginning of what would later be known as the “Bench Press”.

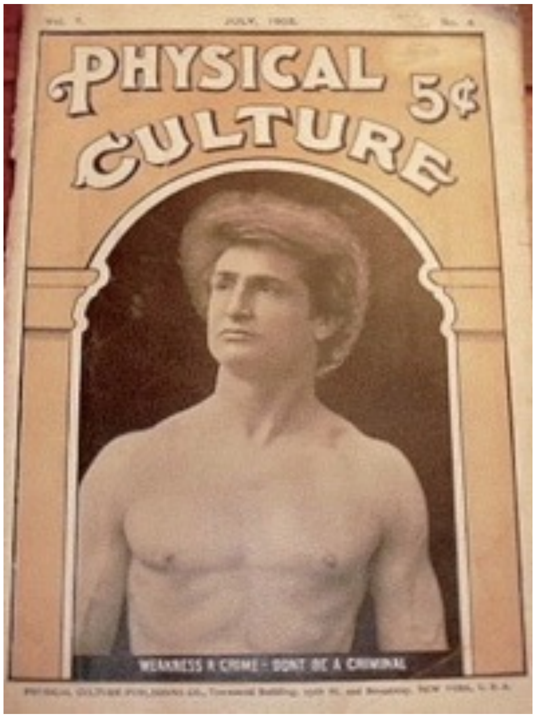


Eugene Sandow (1867 - 1925) (pictured below) is often referred to as the Father of Modern Bodybuilding, because he was one of the first to combine acts of **strength,** with classic poses displaying a **muscular physique**.



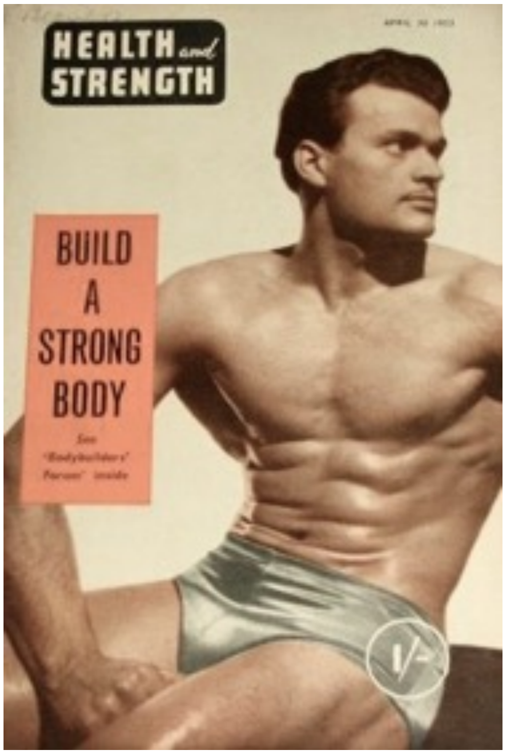


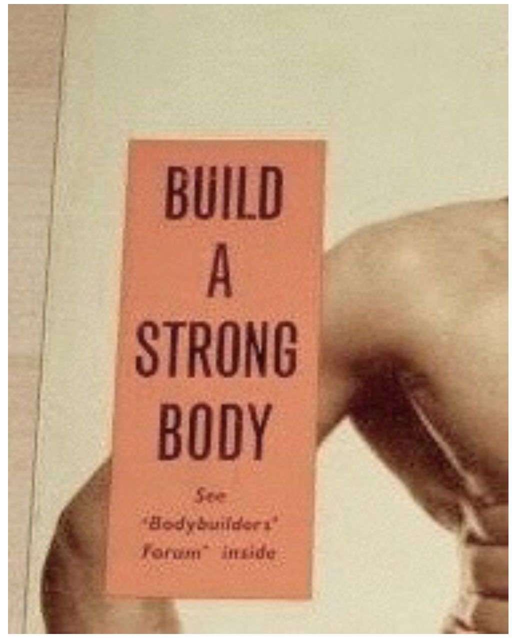
In the early days of “Physical Culture” - the 1900s - the emphasis was mostly on **strength**. A muscular physique was not meant as a goal unto itself. Notice that, on the magazine cover below-left, it reads “**Weakness a Crime - Don’t Be a Criminal**” (banner below the photo).



The magazine (shown above, right) - cover dated 1907 and depicting yet another display of strength - was called **“Health & Strength”**. There is no mention of physique. Clearly, physical strength and health were valued. But, the pursuit of a well-developed physique may not have been considered “honorable”.

On the cover of the 1953 issue of “***Health and Strength***” magazine (shown **below**), we see the words “HEALTH”, “STRENGTH” and “STRONG”, in bold, upper case letters. Then, in **small**, cursive letters (below the “BUILD A STRONG BODY” banner), it reads “*See Bodybuilder’s Forum - inside*”. Again, this seems to suggest that a well-developed physique was either regarded as a less worthy goal, a goal that should not be confessed publicly.

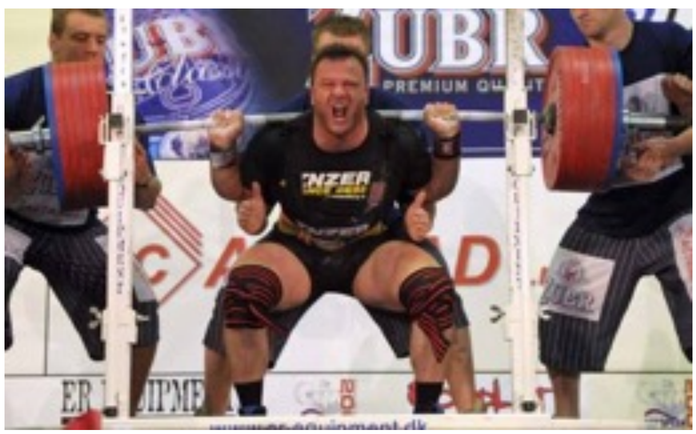




The deliberate pursuit of a muscular physique was likely regarded as vain. As a result, there seems to have been a bias developing **against** the pursuit of "physique development". This bias would have also included **exercises** that were **intended** for physique development (i.e., not intended to move large amounts of weight). It's likely that isolation exercises were discredited - perhaps even ridiculed. However, "isolation" exercises DO increase strength, even though the amount of weight used during the exercise may not be considered "impressive".

In 1920, "Olympic Lifting" became officially recognized as an Olympic sport. Today, it is comprised of two lifts - "**The Clean and Jerk**" (shown below, left) and the "**The Snatch**" (shown below, right). These are meant to test strength, as well technique (balance, speed, coordination and skill).

“Powerlifting” was established as a sport in the 1950s. The lifts that comprise this endeavor include the **Bench Press**, the **Squat** and the **Deadlift**, though these lifts originated well before 1950, in more rudimentary forms. In Powerlifting competition, the goal is to have the highest sum total of the three lifts.



Early bodybuilding was thus heavily influenced by the pre-occupation with “power”, and by the mistaken belief that a well-developed physique **required** a “foundation” in the Power Lifts. But at the root of this belief, was a morality-based adulation of “strength”, and a disdain for the absence of strength. Again, the caption on the “Physical Culture” magazine cover below - “***Weakness a Crime, Don’t Be a Criminal***” - suggests that neglecting “strength” (or perhaps not demonstrating strength) was **immoral**, or at least without virtue.

Other “compound” (calisthenic-type) exercises were regarded an essential part of exercise as well. These included Chin-Ups, Push-Ups, Parallel Bar Dips and Hanging Leg Raises, among others.

Interestingly, these “body weight” exercises had their roots in “**gymnastics**” and “**acrobatics**”, and date back to 2,000 BC. Like the heavy weight lifts, these were also used as exhibitions of “*extraordinary feats of strength, balance, coordination and agility*”. They were not necessarily used only as “the means to an end” (i.e., a process), so much as a test and display of ability.

Here again, we see a value placed on exercises that seems to be based more on strength exhibition - and these became the standard for exercise. Few people today, question the **tradition** of throwing rice at a wedding. They simply comply.   It’s what people are “expected” to do, so they go along with it. Likewise, with these traditional exercises.

Above is a wall painting dated between 1550 and 1450 BCE (the late "Minoan Period"), found in Knossos, Crete. It depicts "bull leaping", which was another one of the "extraordinary feats of strength, balance, coordination and agility" of the day. It seems the emphasis was consistently on "exhibition" - since the early days of man. This underlying emphasis seems to persist today, despite it's primitive mentality.

“Power Lifts” and “body weight / calisthenic” exercises became the accepted norm. Most people embraced these exercises, without questioning their degree of productivity or safety. It’s likely some isolation exercises were also performed, but only **in addition** to the Power Lifts and “body weight” exercises - not instead of them. Thus, it was difficult to ascertain how productive the isolation exercises were, because they were mixed in with the “compound exercises”.

Further, since it was believed that the Power Lifts and “body weight” exercises were foundational, people performed them with added vigor. They performed them for **more total sets** and with heavier weight - and also competed against others with them. It’s obvious, therefore, that their EXTRA effort into those exercise, would have yielded greater results for that reason. Conversely, the exercises that were considered “isolation”, were likely done with **less** vigor, because they were considered incidental. Thus, they naturally would have yielded less improvement.

For a person who is unfamiliar with bio-mechanics, it might seem reasonable to assume that exercises with which they can lift a **heavier** weight, would produce more “mass” (i.e., larger muscles). But this is an incorrect assumption. A muscle that is participating in a compound exercise is being assisted by other muscles, in the lifting of a that weight. A unified effort (multiple muscles participating simultaneously in one lift) will naturally allow a heavier weight to be lifted. However each of the participating muscles may not be working at their individual maximum capacity.

In fact, during a “compound exercise”, some muscles may be working at 100% (of their maximum effort), while others may only be working at 70% or even 50%. Ironically, sometimes a muscle we **most want** to target is working **less** intensely than a muscle which we do **not** necessarily want to emphasize - as we’ll see in the following chapter. **Each** of the participating muscles, however, **could** be worked with 100% effort, by doing exercises that are directly targeted to them, even though a lighter weight would be used.

It’s important to draw a distinction between “lifting heavy weights” and “efficiently loading a muscle”. An individual muscle can be **loaded** MORE**,** even though a lighter weight is being lifted - if it is not assisted by other muscles, if it has better alignment, if the resistance curve is more ideal, or if a longer lever is being used. Conversely, an individual muscle could be loaded LESS during a compound exercise - even though a heavier weight is being lifted - because of these variables.

In 2010, I wrote an article entitled **“The Case Against Overhead Presses”**, for *Iron Man Magazine*, in which I explained the five bio-mechanical problems related to that movement. Some of the problems with the Overhead Press are related to its compromised efficiency (leading to less benefit), while others related to its relatively high risk of injury.

As a rebuttal to my article, a man named Bill Star wrote an essay entitled “In Defense of the Overhead Press”. In his first paragraph, he wrote that he felt “**morally** obligated” to defend the exercise. This is further testament to the fact that **morality** seems to play a subconscious role in the “sanctity” of these Power Lifts - even today. He called my explanation “scientific jargon” and a “smoke screen”, yet offered no science-based counter point. No physics.

Open debate about the mechanics of various exercises is good. Discussing the specific **application** of an exercise, or the **physics** used to evaluate it, are intelligent methods of discourse. But the idea that an exercise needs “defense”, and that someone might think it’s immoral to criticize an exercise because it has been revered for centuries, speaks volumes about why these movements are over-valued today.

Note: Bill Star was a strength coach, with no background in bio-mechanics for physique development.

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Survival & Heroism

Through the earliest years of humanity, man has needed to be strong for the sake of survival. Battle was an integral part of life. Civilizations were built and conquered by way of physical labor and war. “Exercise” was standard practice as preparation for battle among the Babylonians, early Persians, Egyptians, Romans and Greeks. It is thus understandable that the preparation for battle prioritized the development of physical strength, fighting skills, flexibility and endurance.

It’s important to understand that the original idea of “fitness” was rooted in battle-preparedness and labor-preparedness. “***The strongest shall survive***” was not just rhetoric. It was a matter of life or death. People were selected for battle or labor, based primarily on their physicality. The weak were naturally overlooked.

Women selected their mates primarily on the basis of their physicality. The safety and security that a stronger man could provide was important, if not essential. A stronger male counter-part also meant stronger offspring, which also lead to better survival. Women with stronger husbands were more likely to have food, shelter and healthy children. In a harsh world where “productivity” meant farming, construction, fishing and hunting (rather than a desk job), as well as family security (defense from invaders), women depended on a strong man in the home. Physical strength had tremendous value in those days.

Thus, stronger men naturally had more options for female companions. So, in addition to being **more successful in battle** and better able to survive, stronger men were also “rewarded” with females. This gave way to legendary stories of powerful warriors and heroes, which inspired many with hopes of achieving that type of status.

Comic Books & Mythology

It should come as no surprise, then, that many of today's comic book heroes are based on Greek mythology. A wonderful thesis paper written by Andrew S. Latham *, entitled "***Comic Books vs. Greek Mythology: The Ultimate Crossover for the Classic Scholar***", beautifully outlines this relationship. Many of today's comic book super heroes were inspired by the legends of Hercules, Zeus, Poseidon, Neptune, Triton and Perseus - among others. This further perpetuates the notion that physical strength is "heroic", and brings this bias fully into 20th century culture.

(Masters of Arts in English / The University of Texas at Tyler, May 2012)*

Through hundreds of thousands of years of evolution, humans had to embrace the reality that strength and physical ability were essential for safety, survival and battle victory. As a result, we now seem psychologically programmed to have a tendency for "**hero worship**", and a strong desire to be "**heroic**" - even though it's much less useful today, than it was ages ago.

Why are adolescent boys so fascinated with comic book super-heroes? An eight-year-old boy could not possibly know from personal experience that (once upon a time) great physical strength translated to better safety, better survival, better success in battle, better mating opportunities and the admiration of his piers.

Why do we hold modern day sports stars, as well as sports coaches, in such high regard - often more so than brain surgeons. Why do so many athletes risk their health and their lives - boxing and risking concussions in football - even as amateurs (no pay)?

Most of us who live in developed countries, in the 21st century, do **not** live in constant fear that an army of sword-wielding warriors on horseback will suddenly invade our village. We do not have to prepare for that type of battle. We also do not have to go out and plow our fields for food; we simply drive to the grocery store. Today, our ability to attract a mate is more related to our ability to earn a decent income, than it is to our ability to slay a dragon.

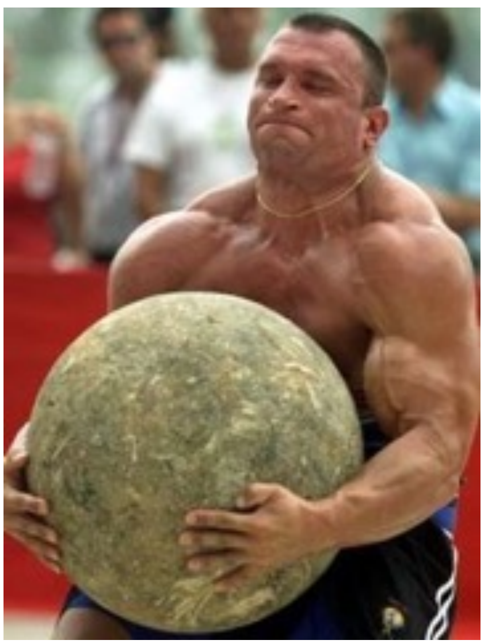
This is not to suggest that strength is no longer valuable, nor necessary. But our day-to-day survival does not rely as much on extraordinary strength as it once did. Today, we have **other** requirements for survival and "success" - namely education and productive skills. A female may still be attracted to a strong man, but it is not as necessary for her survival, nor that of her children, as it once was. Certainly, being "fit" plays a role in one's ability to function better in today's society. But it does not require "superhero" status, as it once did.

Yet, we are still **fascinated** with the "superhero". In a scene from the movie "*The Equalizer*", actor Denzel Washington single-handedly fights and kills six (very tough looking) Russian mobsters, in under one minute's time…..without incurring any type of injury himself. We know this lacks realism, yet we wish we could be that "tough".

In the TV show "*American Ninja Warrior*", competitors go through an obstacle course of extremely difficult (and potentially injurious) physical challenges. Here again, we are mesmerized by the toughness, strength and endurance (abilities that were once essential for survival, but are generally are not useful today) of the show's participants. Does anybody question "why" we are so fascinated with these **heroic** displays of athleticism? Or why the name of the show includes the word "warrior"?

Many of us embrace the trappings (appearances) that "represent" (or we ***think*** represent) strength and/or toughness. Again, it seems that we are hard-wired to be convey the image of being "heroic". Our subconscious minds seem to lead us to a pre-occupation with representing ourselves that way, to the world. We get tattoos which are reminiscent of war paint (or the "dangerousness" of a gang member / criminal). We shave our heads, and grow our beards or other type of facial hair. We build our muscles and we lift heavy objects, even without "needing" to do so for survival.



Consciously or subconsciously, we often “perform” in the gym. Knowing that we are being observed by the others around us, we often tailor our gym activities more toward what would be impressive to watch, rather than to what would be the wisest training strategy for the **fitness** results we seek.

These gym activities may include jumping up to a four-foot platform, double or triple speed jump-roping, acrobatic-type of chin-ups, one arm push-ups, etc. Needless to say, these types of demonstrations and abilities have very little usefulness in normal, day-to-day life. These activities improve our performance ability, more than they improve our fitness level - and most people doing them know this. But clearly performance ability has a greater importance.

The fact is that “extraordinary feats of strength” and extreme athleticism are VERY highly regarded in today’s society, despite that the fact that our reliance on those abilities (for survival) is much less than it once was. That fine. But we should acknowledge that our **fascination** with extraordinary feats of strength and athleticism is influencing our ability to accurately evaluate certain exercises, even when it lacks logic.

Departure From Logic

As one example of how illogical this debate has become, let’s look this type of exercise called “Closed Chain”.

Some “fitness experts” use the terms “compound exercise” and “closed chain” almost interchangeably. Technically, “closed chain” exercise refers to exercises that have a “grounded” (or fixed) resistance source. This would include Push-Ups, Chin-Ups, Parallel Bar Dips, Squats, etc. In these cases, either the hands or the feet are in contact with the ground, or on some other type of fixed, immovable surface. Then, body weight (plus, possibly some additoinal resistance) is pushed or pulled from that fixed surface.

Conversely, an “open chain” exercise would be described as one where the resistance is mobil (not stationery). Examples of this would be a Barbell Bench Press (the barbell is moving), a Cable Triceps Pushdown (the hands, attached to the handle, or moving) and a Leg Extension machine (the Tibia is moving through space, as it pushes against the lever arm of the machine).

Proponents of “compound exercise” often favor “closed chain” over “open chain”. In fact, many physical therapists favor “closed chain” over “open chain” because they were “taught” to favor them, in their university courses. The **rationale** for this might be the idea that “closed chain” more closely resembles the types of activity found in the real world - as opposed to using apparatus, like barbells or machines. In fact, they often say that “closed chain” is more “functional” than are exercises which employ some type of hand-held weight or machine.

But a working muscle would have no “idea” what is happening outside of its individual function. For example, a Latissimus muscle pulling on a humerus (upper arm bone) would not “know” what is making the humerus challenging to pull. It could be a chin-up bar, and one’s body weight hanging from it…..or it could be a Lat Pulldown bar, against which a cable is pulling upward. Yet, a proponent of this theory would regard the Chin-Up as “good”, and the Lat Pulldown as “bad”. The Chin-Up would be encouraged, and the Pulldown would be discouraged - even though there is essentially no difference between the two (as far as the Latissimus is concerned).

The same is true for Squats. A proponent of this theory would say “Squats are good because they are ‘closed-chain’, and Leg Extensions are bad because they are ‘open-chain’.” However, the Quadriceps muscle (as well as the knee) would not “know” against which type of resistance its having to work.

It could be that one’s body weight is being pulled **downward** by gravity, while the Tibia (by way of the foot on the ground) is pushing **upward** (i.e., when doing a Squat). Or it could be that the platform of a Leg Press machine is pushing **toward** one’s torso, and the Tibia is pushing the platform **away** from the torso. Either way, the Quadriceps is doing the one-and-only thing it CAN do, which is to extend the knee.

*(Note: foot placement on the Leg Press does alter the **percentage** of the resistance that is loaded onto the Quadriceps, but the mechanism of the knee and Quadriceps are still the same.)*

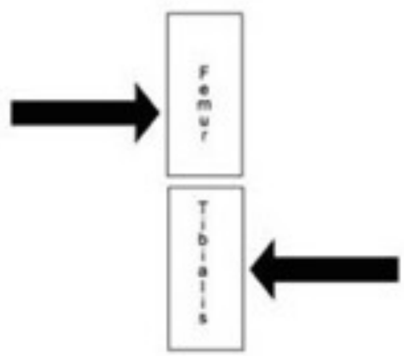
Likewise, the Pectorals would not “know” whether a Push-Up is being done, or a Barbell Bench Press is being done. In the first case, the **Pectorals are pulling the humerus toward the sternum**, which causes the hands to push down against the ground, which causes the body to rise. In the second case, the **Pectorals are pulling the humerus toward the sternum**, which causes the hands to push upward against a barbell, which causes the barbell to rise. But in both cases, the Pectorals are doing the exact same thing - pulling the humerus toward the sternum (which is where the origin of the Pectorals are situated), thereby “adducting” the humerus in a forward direction. There is absolutely no difference between the two - assuming the weight of the barbell, is commensurate to one’s body weight.

(Note: A push-up requires some work to be done by the abs and hip flexors, in order to prevent the torso from collapsing. During a Bench Press, this is not required. However, in terms of the Pectorals, there is essentially no difference.)

Leg Extension "Shearing"

Proponents of "compound exercise" typically recommend Squats over the use of a Leg Extension machine. Part of their rationale is a claim that the perpendicular force being applied to the ankle - during a Leg Extension - has a "shearing effect on the knee".

In order to illustrate this, they usually use the graphic below, which shows two vertical rectangles - one stacked above the other, representing an upper leg bone and a lower leg bone. They also show two horizontal arrows pointing right on the upper "bone" and left on the lower "bone". The suggestion here is that a **perpendicular force** placed against the Tibia would cause the entire Tibia to shift inward, and separate from the knee.



Shear Force

This is absurd. First, there are countless similar situations that occur in various other exercises, and no such concern exits. In fact, most exercises we do in the gym produce a perpendicular force against a bone. Were it not for perpendicular forces, there would be no resistance to work against. As you know, a **parallel** lever is a **neutral** lever.

However, the most obvious reason "shearing" does not occur (*with any significance*) with Leg Extensions, is that in order for the Quadriceps to extend the knee, it would have to produce a force that is approximately 20 times greater than that which is pushing against the ankle. This is due to the magnification caused by the length of the tibia. That force (produced by the Quadriceps, by way of the Patella tendon) is pulling the tibia upward. This produces an anchoring effect that is 20 times greater than the force pushing perpendicularly on the ankle. There is simply no way that the tibia could shift inward, while it's being so firmly anchored. This can be easily demonstrated with an anatomical model.

In the photo above, the RED arrow represents what might be a 30 pound (per leg) resistance, pushing perpendicularly against the ankle (distal end of the Tibia), provided by a Leg Extension machine. The GREEN arrows represents the (approximately) 600 lbs. of force required - and therefore produced by the Quadriceps by way of the Patella Tendon - pulling upward on the Tibia.

(Note: For a full explanation of the fallacy of this "shearing" issue, please see: http://www.labrada.com/blog/workouts/is-the-open-chain-closed-chain-exercise-philosophy-shear-non-sense/) - ***"Is the Open Chain / Closed Chain Exercise Philosophy Shear Non-nonsense?")***

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So, it's impossible to cause the knee to "shear" by doing Leg Extensions, and it's very easy to prove it. Yet, "educated people" warn against the danger of "knee shearing" when using a Leg Extension machine. They fail to see the obvious lack of logic that that represents.

To make matter worse, these same “educated people” then recommend *Side Planks*. However, *Side Planks* also create a perpendicular force against the Tibia (by way of the foot) - but THIS perpendicular force is trying to bend the knee **sideways**.

Let’s assume this person (shown above) weighs 200 pounds. He’s suspending himself on two points, so - he’s loading each of the two points with somewhere between 50 and 100 pounds. Let’s assume the lesser amount is pressing upward on the side of his right foot. The average length Tibia is approximately 17 inches, so that the magnification of that 50 (to 100) pounds would 17-fold, by the time it gets to the knee. This *Side Plank* would therefore produce approximately 850 pounds of “**sideways**” force on the knee - trying to bend it in a direction it was NOT designed to bend. And there is no “Quadriceps” available here, to produce any kind of anchoring. **Only the knee tendons and ligaments are supporting the knee during *Side Planks*.**

How is this “more safe” than a simple Leg Extension?

This is typical of the illogical assumptions that are made by people who promote “compound exercise”.

There are dozens of other examples we could review, but I think the point has been made.

Summary

The point of this chapter is to suggest that we stop assuming our “power obsessed” predecessors were correct in emphasizing the Power Lifts, for fitness and physique development.

Power Lifts have a place in society, but they are not necessarily the better choice of exercise for fitness and physique development. When we evaluate each exercise using a set of standards that are physics-based, we can clearly see how much load is which muscle, and where the risks are.

Every culture in every society has been influenced by beliefs and biases that were NOT rooted in truth or logic. Our industry is no exception. In the fitness field, we have largely failed to evaluate exercises by way of physics. We can specifically quantify the load that each lever (i.e., limb) is placing on specific muscles, tendons and ligaments. Instead, we have given many exercises a “pass” (or a “double thumbs up”) on the basis of tradition and emotional bias - when they actually have less benefit than various alternatives.

In the next chapter, we will review a number of side-by-side comparisons of “compound" and “isolation” exercises, which will further help clarify what is “good” or “bad” with each type of exercise, from a bio-mechanical perspective. Each exercise must be evaluated separately, because each has its own unique set of bio-mechanical circumstances. It’s foolish to assume that ALL exercises of one type are “good” and ALL exercises of the other type are “bad”.

Chapter Thirteen

Peripheral Recruitment

Comparison of Compound vs Isolation Exercises

The conventional wisdom among many in the fitness and bodybuilding communities has been that compound exercises build power and mass, and that isolation exercises are only for shaping.

Some trainers and physical therapists believe that compound exercises are more "functional" than isolation exercises. The suggestion is that strength gained from compound exercises is more useful in day-to-day life, than strength gained from isolation exercises.

Some have suggested that isolation exercises are "dysfunctional" - meaning that they have a higher risk of injury, or cause of a loss of coordination.

Many believe that compound exercises "save time", because they work three or four muscle groups at one time, as compared with isolation exercises, which only work one or two muscles at a time.

This chapter will evaluate these beliefs.

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For those who have not read the previous chapter, the standard definition of a "compound exercise" is an exercise that involves multiple joints and/or muscles (typically three or more) simultaneously. The standard definition of an "isolation exercise" is an exercise that typically involves one muscle and one joint. An exercise that involves two joints could go either way, depending on the difficulty of the movement.

Examples of compound exercises are Squats, Deadlifts, Parallel Bar Dips, Chin-Ups, Push-Ups, Bench Press, “Hang Cleans”, Bent Over Barbell Row, etc.. Examples of isolation exercises are Standing Barbell Curls, Supine Dumbbell Triceps Extensions, Leg Extensions (on machine), Standing Side Dumbbell Raises, etc..

Four assertions are stated above, in support of compound exercise.

1. Compound exercise = more power and more muscle mass

2. Compound exercise = more functional / more useful in day-to-day life

3. Isolation exercise = disfunctional / increased injury risk

4. Compound exercises = time saving

In brief, here is the “short answer” on each of these. The rest of this chapter will elaborate further on these.

1. Each of the three or four muscles that may be contributing during a compound exercise is working in its “own world”. It is performing its contraction, as best it can, given the circumstances of that exercise. Each muscle is “unaware” whether it’s working alone, or as one of several muscles.

If a muscle is working at maximum capacity, with full range of motion, it will grow. This is equally true, whether it is working in unison with other muscles, or alone.

That is the ultimate determining factor of “muscle growth”. It is not “how much total weight is moved, by a group of muscles” - because not all contributing muscles (during a compound exercise) will be working with equal intensity, nor with equal range of motion.

2. Proponents of compound exercise sometimes argue that “life is not an isolated exercise”, and that is why compound exercises are “better”. The fact that tasks in life often require multiple muscles working simultaneously, does not automatically mean that strength gained from an isolated exercise is not use-able in those tasks.

It is true that a person who consistently performs a compound exercise, WILL improve their coordination and skill in that particular exercise / “lift”. Consistency and frequency improve any skill. That skill (and the strength associated with it) can then be used in activities which are similar to that particular exercise / “lift”.

But to suggest that a person who does only compound exercises, will be more capable of handling day-to-day activities, as compared with a person who only does isolation exercises, is leap of logic. The body / brain / central nervous system are very good at coordinating the strength of all the muscles, regardless of how that strength was gained.

3. The assertion that isolation exercises might “cause” dysfunction - a loss of coordination - or that they pose a higher risk of injury, is nonsense.

A movement that has more moving parts (i.e., a compound exercise) and which often requires the use of one’s entire bodyweight (i.e., does not offer the option of using a lighter weight), would naturally have the higher injury risk.

Isolation exercises - by definition- are exercise that are designed to follow the exact motion of a particular muscle (and its joint), and would therefore be a more natural movement for that particular muscle and joint. An exercise that involves the participation of several muscles and joints, may suit some muscles and joint, but not others.

There is no evidence that isolation exercises produces a lack of coordination - not even empirical evidence. I have yet to see anyone become less coordinated because they used isolation exercises, in over 40 years of being “in the trenches”.

I have used mostly isolation exercise for most of my career, and have only gotten positive results. I might add that many of my contemporaries have had numerous orthopedic surgeries - including shoulder replacements, hip replacements, spinal fusion, etc. I am still competing in bodybuilding at the age of 56, without any injuries or joint pain. I can still play basketball, dance, swim, and any of the other activities I did when I was a young adult.

4. In terms of saving time - this would theoretically be true, but only if each muscle participating in a compound exercise were receiving the same quality muscle stimulation as could be achieved with separate isolation exercises. That would eliminate the need to do another exercise for those participating muscles. But that is not the case.

Most bodybuilders who do a compound exercise, ALSO do separate exercises for those individual muscles. In other words, while multiple muscles may be participating in a compound exercise, their participation is not enough to qualify as a “good enough” for those muscles - at least not for the person who wants optimal results.

On the other hand, a person who does one “good” isolation exercise for each primary skeletal muscle, does **NOT need to do any additional exercise** for those muscles. Therefore, the person saving time is the one who does only the isolation exercises.

Of course, if a person is content getting 40%, 50% or 80% as good a stimulation per muscle, during a compound exercise, as compared with an isolation exercise - than that person might consider the compound exercise a “time saver”. However, most bodybuilders want 100% benefit for each muscle, and most compound exercises do

NOT deliver 100% benefit. In cases like this, the compound exercise would be an unnecessary waste of time and effort.

Comparing the Effectiveness of Compound Exercise vs. Isolation Exercise

To be clear, the comparison we'll be making here is an evaluation of these two types of exercise for the primary purpose of muscular development. This is different than training for a particular sport, or training for Power Lifting.

Our primary goal is visible development of skeletal muscle, but this is not a purely cosmetic pursuit. There is no way of making a muscle larger, without making it stronger. The process by which a muscle is developed requires the loading of that muscle, and then causing it to contract against that resistance. A muscle will naturally increase its strength in that process. It is inevitable.

In addition to a strength increase, muscles naturally improve their endurance, when exposed to resistance exercise and fatigue. Other benefits, including improvements in metabolism and the cardiovascular system are also likely to be realized, in the process of resistance exercise.

In the chapters that have preceded this one, we have learned that a number of physics-related factors influence how much load is placed on a given muscle, regardless of the actual weight being lifted. These factors include lever length, lever position, alignment, etc.

For example, we demonstrated how a Triceps can be loaded with only 119 pounds of resistance, when a 180 pound man performs Parallel Bar Dips - OR - it can be loaded with 240 pounds of resistance when a person performs a Supine Dumbbell Triceps Extension with a pair of 20 pound dumbbells. More weight used does NOT automatically translate to a muscle being loaded more. A muscle can be loaded more with less weight, if certain bio-mechanical factors are present.

So the question we must ask ourselves, in order to adequately compare exercises, is this: **"What are the bio-mechanical factors that most contribute to muscle growth?".**

Those bio-mechanical factors can then be used as a "Litmus test" for evaluating any exercise. Without this knowledge, one would be relegated to judging the productivity of an exercise ONLY by the total amount of weight lifted - which is a grossly inaccurate method.

Here are the bio-mechanical factors that most contribute to muscle growth:

1. Ideally, a muscle should pull its operating lever directly toward its origin. Thus, an ideal exercise would provide a **"pathway of movement"** that allows the operating lever to move directly away from, and then directly toward, the origin of a muscle. This produces muscle lengthening (stretch) and muscle shortening (contraction) - which results in Dynamic muscle contraction.

2. Ideally, the pathway of movement of an exercise should provide a mostly full **"range of motion"**.

3. Ideally, the **direction of resistance** for a muscle would be in **alignment** with the direction of movement of the limb. This would allow most of the resistance to load the target muscle, and would reduce the risk of injury.

4. Ideally, the **direction of resistance** would provide **"early phase loading"** to the target muscle.

5. Ideally, an exercise would utilize a mostly **"active" lever** (limb) during the range of motion, for maximum efficiency.

6. Ideally, an exercise would allow for **natural joint motion** - without any unnecessary contortion, compressing or impinging.

7. Ideally, an exercise should provide relief from any **"mechanical disadvantage"**, where ever it may present in an injury risk.

8. Ideally, an exercise should be performed with **deliberate muscle force**, rather than with momentum ("swinging" / "cheating").

The amount of weight lifted (as a percentage of maximum effort) during an exercise DOES matter, <u>but not at the exclusion</u> of the above criteria. Lifting heavy weights, while not complying with the above factors, will still lead to **some** muscle growth - but not in the most efficient manner possible, and with a higher injury risk. The "cost" will be higher, and the benefit will be lower.

For example, if a compound exercise provides half as much range of motion to a muscle, as compared with isolation exercise, it means that the compound exercise will not be "good enough" as the sole exercise for that muscle, for that workout. An additional exercise for that muscle will be needed. But one good exercise, with sufficient range of motion, is all that is actually necessary. So why spend the extra energy, unproductively?

When evaluating a compound exercise, we should first look at every lever that is involved in the movement. We can easily see which ones interact perpendicularly with gravity, and to what degree they do so. Once we're familiar with the anatomy (Chapters 18 through 25), we will know which muscles are involved in moving those levers.

Then, we can decide whether or not the muscles involved are muscles we WANT to be involved. We can also decide whether a muscle we want to be targeting is getting "most" of the work in that movement, or if it only working "peripherally". Maybe a muscle that we do not want to emphasize is working more (getting more load, and more movement) than our target muscle (i.e., as is the case with *Leg Raises* and *Parallel Bar Dips*).

We can use the 8 criteria listed above, to evaluate each lever and muscle involved during a compound exercise or an isolation exercise.

We can see whether or not there is any joint strain, in that particular movement. If joint strain (twisting, impingement, etc.) does occur during that exercise, we can judge whether that same muscle could be worked as well, or better, using an exercise that does not require that joint strain.

Obviously, it would be foolish to choose an exercise that strains the joint, but does not work the muscle better or "as well" - when a better option exists. And only bio-mechanics / physics can determine what a better option is, and why it's better.

Almost every exercise is a "compound exercise" - to some degree. Sometimes this "peripheral recruitment" of assisting muscles is productive. Sometimes it's **un**productive. Sometimes it interferes with the successful loading of the target muscle. Sometimes it creates an injury risk.

We should examine each exercise without **any bias** - neither for, nor against. We must be like a jury in a courtroom that looks only at the bio-mechanical facts. We must ignore any preconceived notions or traditional beliefs that exist about an exercise. Then, we can evaluate what each lever (limb) is doing, during that exercise, and decide whether or not the mechanics of the exercise meets the criteria identified above, for each participating muscle.

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What Is Peripheral Recruitment ?

Peripheral Recruitment refers to muscles that **participate** during a given exercise, but may not be the muscle(s) one chooses to prioritize. Peripheral Recruitment happens during compound exercises, but it also occurs during many isolation exercises. Sometimes this is acceptable, while other times it is problematic.

As an example, let's look at the **Standing Barbell Curl**. It is generally considered an "isolation" exercise for the Biceps. However, the Biceps are not the only muscle that is working. The Lower Back (Erector Spinae) is also working, because it's preventing you from falling forward, as you do the Curls. The Erector Spinae are working **isometrically** in keeping the person upright, while the Biceps are working **dynamically**. In addition, the Glutes and Hamstrings are also participating - “peripherally” - in maintaining posture, during this exercise. This is acceptable.

When people do a ***Hanging Leg Raise*** (shown below), they typically hold onto a Chinning Bar, with the arms straight. Then knees are then brought up toward the chest, or the exercise is done with straight legs.

The intended “target” of this exercise is the Abs (i.e., Rectus abdominus), but there are a number of other muscles that also are “recruited”. The muscles of the hands must work to maintain the grip; the forearm muscles are also working; the hip flexors are working quite a lot; and the Quadriceps are working to a degree (more so when the legs are straight). In addition to these assisting **muscles**, there may also be some degree of strain to the shoulder joint.

A proponent of compound exercise would argue that the ***Hanging Leg Raise*** a “good” exercise, because it’s working a number of different muscles. They would suggest that this saves time, and also creates a greater caloric demand, than would occur during an isolated abdominal exercise. That may SOUND appealing. However, upon closer inspection, we’ll see that the ***Hanging Leg Raise*** has some serious problems.

In regard to the claim that it saves time, it’s worth asking the following two questions: “***Is the muscle I <u>most</u> want to prioritize working the most, during this exercise?”, and “Are the other muscles that are participating, ones that I <u>want</u> to work?”.*** For both questions, the answer is “**NO”**.

The muscle working the most, during this exercise, is the Hip Flexor group - and that is not a muscle you likely want to prioritize. The Abs are working second-most, but a distant second. In other words, if the Hip Flexors are working at a level 10, the Abs are working at a level 2.

The muscles of the hands and forearms are more “strained”. If your objective is to develop the forearm muscles, you’ll need to do “wrist flexion” and “wrist extension”, in order to produce any kind of visible development of the forearm muscles.

You could also do without the shoulder joint strain.

“Hanging Leg Raise” is a compound exercise, but it’s mostly a waste of time and energy.

Note: The use of straps (attached to the chin-up bar, by which a person can then support their bodyweight without the use of their hands) does eliminates the potential hand and forearm strain. However, these straps do not change the fact that the Hip Flexors are working significantly more than are the Abs.

A standard Ab Crunch would load the Rectus abdominis better, and would not strain the shoulder joint, nor strain the fingers, hands and forearms. It would also not waste energy unproductively on the hip flexors. But it’s considered an “isolation exercise”.

Proponents of compound exercise would likely discourage doing standard Ab Crunches - even though it provides a greater benefit to the target muscle (the Abs), while wasting less unproductive energy, and having a lower injury risk.

Proponents of compound exercise often recommend *Planks* as an alternative to Ab Crunches. They would say that *Planks* are a compound exercise because it involves the Abs, as well as the Hip Flexors and Quadriceps.

Yes - *Planks* do "involve" the Abs, Hip Flexors and Quadriceps, but they do so in a mostly unproductive way. Muscle tension without movement is "isometric", which has been shown to be is less productive than dynamic muscle tension.

Of the three primary muscles "involved" during Planks (The Abs, Quadriceps and Hip Flexors), only two of the three are important to us. Hip flexors are not something anyone would typically say "needs work". People do care about their Quadriceps development, but THIS is not the best way to get it. The Quads - like all muscles - benefit more from dynamic exercise, WITH movement. Full extension and contraction - with mostly full Range of Motion.

The muscle that people MOST want to develop with this exercise is the Abs, but they are much less likely to develop **visible** abdominal development from Planks, as compared with standard Ab Crunches. Again, this is because Planks are isometric and Ab Crunches are dynamic. Plus, the strength they gain from Planks is limited to only in the one position. Ab Crunches produce abdominal strength through the entire range of motion.

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In Chapter 2, we discussed "Active Levers and Neutral Levers". We talked about how the standard Barbell Squat uses a tibia that barely arrives at an angle that is 30 degrees from "neutral". This means that only about 30% of the weight that is on your back, is loading the Quadriceps. Conversely, you could do *Cable Squats* with half as much weight, and load your Quadriceps with as much, or more resistance, and NOT have the spinal compression created by *Barbell Squats*.

Interestingly, they are both "Squats" - so they could both be classified as compound exercises. However, sometimes compound exercises are popular because they allow people to use more weight. The ability to use a lot of weight, during an exercise, should not be the deciding factor in regard to exercise selection, for the purpose of muscle building. But this also shows how some compound exercises are “great”, and others are not so good.

Compound exercises which “**allow**” us to use a lot of weight (like Squats), are technically inefficient. Let me re-phrase that last sentence, so that you’ll understand it better. Those exercises REQUIRE us to use a lot of weight, in order to load our target muscles enough.

This is due to using lever (limb) angles that are NOT mostly “active”. Rather than using lever angles that produce maximum magnification, we use lever angles that only deliver a fraction of the load we’re using, to the muscles involved. We therefore compensate by using **more** weight, but that adds to the “cost” of the exercise.

Instead of gravitating toward Squats and Leg Presses (for example) - exercises that **allow** us to use heavy weights - we should ask ourselves WHY we are able to use such heavy weights during those exercises. Let us not fool ourselves into thinking we are “Herculean”, while doing those exercises.

Try loading a 200 pound barbell onto the front of your shoulders - as if you were going to do Front Squats - and then do a Sissy Squat with it ! You will **quickly** realize that the angle of your Tibia make a HUGE difference in how much weight your Quadriceps can actually move. As noted in Chapter Two, the effective **length** of the femur is also reduced, during Barbell Squats. This results in a significant reduction in the magnification of resistance, which loads the Glutes.

Although the heavy weight we use for Squatting is not all going directly to our target muscles, it is still burdening our skeleton, spine, joints and possibly a number of smaller, non-target muscles. Eventually, this takes its toll - and it is not necessary. We can get more reward for less cost, by using better lever angles (selecting better exercises) - and it would be wise to do so.

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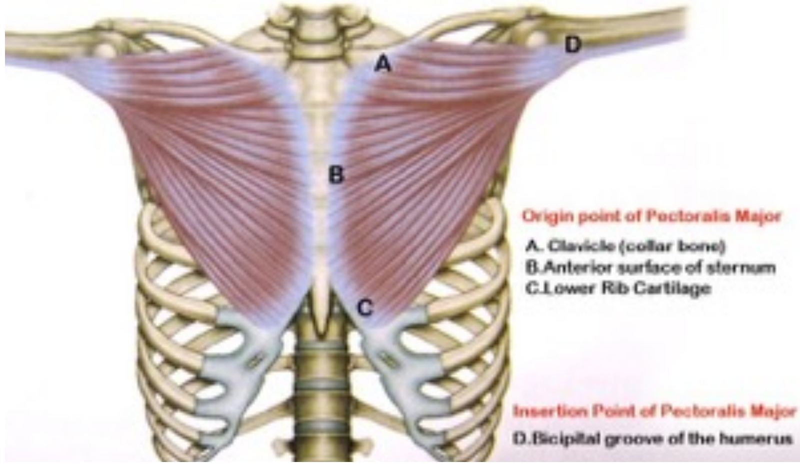
As mentioned above, among the 8 bio-mechanical factors that most contribute to muscle growth, a muscle grows better when it is performs a movement (exercise) that resembles its ideal anatomical motion.

For example, the Pectoralis major ideally moves the humerus toward one of its points of origin. These are mostly located on the sternum, but also (a small percentage) on the ribs (the “costal” fibers) and (another small percentage) on the clavicles (the “clavicular” fibers). For this reason, a “good” pectoral exercise will produce a movement that moves the humerus parallel to those fibers.



Now, let's compare two exercises - ***Parallel Bar Dips*** and ***Decline Cable Press*** - to see which one allows a better anatomical movement for the "Costal" Pectoral fibers.

In the comparison photos above - on the left - you can see the “contracted” position of the Pecs. On the right - you can see the stretch position. Now, go up and look at the anatomical illustration, and notice how the fibers travel inward - toward the center of the torso. The Decline Cable Press - shown above - is the better movement for the Pectorals. “Traditionalists” would favor the Parallel Bar Dips, but not because it is bio-mechanically superior. They would favor it because it’s considered a “compound” exercise - even though it is actually inferior (compared to the latter exercise), for Pectoral development.

Even the Decline Dumbbell Press - illustrated below - is far superior for the Costal Pectorals - as compared to Parallel Bar Dips. This is because - ideally speaking - the humerus (upper arm bones) should move outward on the eccentric phase of the movement, and inward (toward the center of the torso) during the concentric phase. This provides the best **elongation** and **contraction** of the Pectoral fibers.

In order for this to happen, the width between the hands should move “out” and “in”. Look at the distance between the hands in the illustration below, and above - in the stretch position and the contracted position. The arms (and hands) are not free to move “out” and “in” during Parallel Bar Dips, because the bars don’t move.

Some people would consider the exercise above (*Decline Dumbbell Press*) an “isolated” exercise, and would therefore dismiss it. While it’s true that it “Peripherally Recruits” fewer muscles than does *Parallel Bar Dips*, it works the Pectorals far better.

So, when analyzing an exercise like *Parallel Bar Dips* - for Pectoral development - we must see if the movement of the operating levers is correct. With *Dips*, it is not ideal and there are better options.

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The Bench Press is considered a “foundational” exercise by many people. It is regarded as a compound exercise, which works mostly the Pectorals, along with the Triceps and the Anterior Deltoids. In addition to being used for muscular development, it is also considered a “strength builder”.

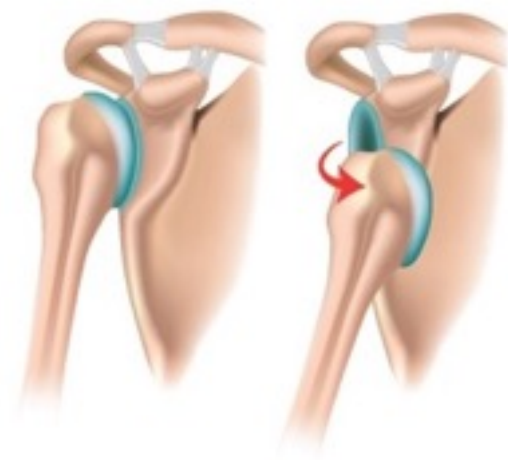
As noted in the beginning of this chapter, any exercises that involves resistance is a strength builder. Why would the Bench Press build strength any better than would Supine Dumbbell Presses? In fact, it would not. Certainly, a person can lift a heavier weight when doing a Barbell Press, versus a Dumbbell Press. But that doesn’t mean that one builds strength “better” than the other.

People tend to use the Bench Press as a “barometer” of strength, so they tend to use heavier weights on this lift, than they do with dumbbells. They are more likely to perform a One Rep Max on the Bench Press - or maybe attempt two or three reps with a Bench Press. Not so, with dumbbells. But doing super heavy weight, for one to three repetitions, is NOT the best way to build the Pectoral muscles. So, at the very least, we should acknowledge that those are two separate goals.

While it may satisfy the ego - knowing that one can Bench Press a “respectable” amount of weight (i.e., 400 + pounds tends to be the usual goal, for men) - it does **not** contribute to Pectoral development (6 reps is the low end of the scale, for hypertrophy). And, it is very dangerous - there is a tremendous mechanical **dis**advantage that occurs at the bottom of the movement, and that’s where most Pectoral ruptures occur.


The three bodybuilders shown above, all tore their right Pectoral - evidenced by the deformity. The severity of each person's rupture, as well as the pose they are using, account for the difference in degree of deformity displayed.

But the point is that if these gentleman had simply stayed focused on the goal of developing the Pectoral muscles, they likely would not have attempted as heavy a Bench Press, as they did. The "rule" of Bench Press is that the bar should come down



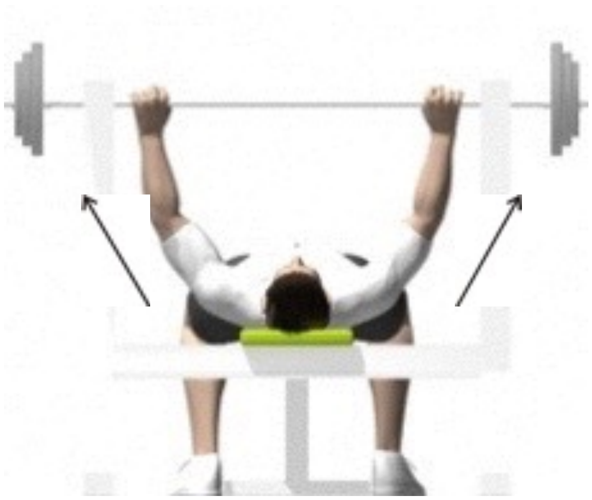
and touch the chest, before being pushed back up. This requires too much range of motion on the **lower end**, where the mechanical disadvantage occurs.

The other potential consequence of doing a very heavy Bench Press, is illustrated above.

At the bottom of the movement, when the bar is touching the chest or is near it, the Pectoral muscle is pulling the humerus mostly “in” - toward the sternum - because that is where its origins are. This mechanical disadvantage dramatically increases the force requirement, such that the muscle can actually pull the humerus out of the Glenoid socket. The illustration above-right, shows the humeral head pulled forward.

What is not shown, in the illustration above, are the tendons that attach to the humerus. So, when the humeral head is pulled out of socket like this, the tendons of the Infraspinatus, Teres major, Latissimus, Posterior Deltoid and Lateral Deltoid, all get pulled forward too. Some of these may rupture, due to being pulled too far forward. Needless to say, this would be a very painful injury. One is likely to have shoulder pain, and (even if surgically repaired) possibly some dysfunction, for the rest of their life.

On the upper end of the movement, there is insufficient range of motion of the Pectorals. In the illustration below, you can see that dumbbells could be brought together another 20 degrees, beyond that which could be achieved when using a barbell. In no other exercise do we casually dismiss that final 20 degrees of the range of motion. Yet - because it’s “the Bench Press” - we ignore it. The fact is, insufficient range of motion compromises muscle building results.

If you were to put oil on the barbell - before performing a Bench Press - you would discover (during the actual lift) that your hands slide **OUTward** on the bar (assuming a “standard” grip on the bar). What does this tell us?

Ideally, the Pectorals “want” to pull the humerus **INward** (their action is “lateral adduction”) - toward the sternum, thereby creating an arc around the shoulder joint. The movement during a Supine Dumbbell Press is “**circular**”. However, a Bench Press tends to become a linear movement, whereby the person is forced to Press “outward” - evidenced by the hands sliding outward on the bar when it’s oily. This demonstrates that there’s **less** Pectoral work than one might think, and more Triceps work than one probably wants - when Bench Pressing.

The Triceps work that occurs during a Bench Press is not a complete range of motion. If one wanted to fully develop their Triceps, the Bench Press alone would not suffice. They would need a dedicated Triceps exercise, utilizing a full range of motion. As mentioned before, this is redundant. One good Triceps exercise is all that would be needed, and the Triceps participation in the Bench Press would then essentially “wasted energy”. Bench Press PLUS a Triceps exercise would not result in better Triceps development, beyond that which can be achieved with just one good Triceps exercise.

So, although many people revere the Bench Press - often asking “how much do you Bench” - it’s actually a compromised exercise. It encourages too much range of motion at the bottom, insufficient range of motion at the top, a slightly incorrect direction of humeral emphasis, more Triceps than is necessary but not enough to make it fully productive, and a (pier encouraged) invitation to be used as a measure of “strength” rather than a method of Pectoral development.

The illustration below-left shows the descended position of a Deadlift. The photos below-right show Arnold Schwarzenegger performing a Bent Over Barbell Row. Both of these exercises are considered compound exercises. The Deadlift, in particular, is revered as a “foundational” exercise. Let’s examine them a bit more closely.

In both of these exercises, we can see that the torso in in a perpendicular - or at least semi perpendicular position - relative to gravity. Therefore, the torso (as a lever) is mostly (or completely) “active”. The muscles that are holding the torso in that position, are therefore fully loaded. This would be the Erector Spinae. - the muscles that run alongside the spine, from the back of the pelvis up to the base of the skull.

The femur - especially in the illustration above depicting the Deadlift - is somewhat diagonal. This means that it’s fairly active. Its operating muscle(s) are the Gluteus and the Adductors, with some “peripheral recruitment” from the Hamstrings.

During a Deadlift, the spine is typically held in an arched posture - despite the forward lean of the torso. So, the Erector Spinae are working isometrically. Meanwhile, the movement is occurring mostly in the Hip Joint. That is the primary “pivot”. That joint is crossed by the Glutes and the Adductors, so they are doing the majority of the work in that movement. They are working dynamically - lengthening and shortening, to produce movement.

Like the Bench Press, this exercise has been promoted as a “strength builder”, so people often tend to use quite a bit of weight. Again, this becomes fairly risky - especially if the person doing the exercise is careless, and allows their spine to roll forward. This could easily cause a spinal disc rupture. But even if the spine is held perfectly “straight” (semi-arched is better), what (**specifically**) is the goal of this exercise?

The Glutes and Adductors are getting some good dynamic work, but there are other exercises that do a better job at that (e.g., *Cable Squats* or *Lunges*), without the heavy load on the Erector spinae. And there are better exercises for the Erector spinae (e.g., *Seated Spinal Extension*), which allow them to work dynamically instead of isometrically. This would allow them to get better stimulation, without having to use so much weight.

Also, when the Deadlift’s range of motion is concluded, and the person is standing upright, the downward pull on the barbell compresses the spine. Spinal compression is serious problem, especially as we get older. There are millions of people who struggle with spinal compression, who never held a 200 pound bar on their shoulders. In other words, we don’t need any help adding to the spinal compression problem. The less spinal compression we do in our lifetime, the better. Why do a Deadlift - which is not the best exercise for the Glutes and Adductors, nor for the Erector Spinae - and increases the likelihood that we’ll have spinal problems later in life?

A similar thing could be said about the Bent Over Barbell Row. In the chapter addressing “Opposite Position Loading”, we discussed how (the origin of the) neither the Lats nor the Trapezius are positioned directly opposite the downward pull of gravity, during this exercise. However, the Erector Spinae IS positioned directly opposite resistance. So, this exercise loads our target muscles LESS than what we want, and our non-target muscle(s) MORE than what is ideal.

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Summary

We must not assume that all compound exercises are “good”. In fact, their value a “fitness exercise” or as “bodybuilding exercise” has been overestimated for years.

Certainly, there is a benefit in having a strong back. However, this does not require one to Deadlift 300 pounds. For fitness, light Squats and light Deadlifts - using proper form and no more than perhaps 50 pounds - would be useful. For bodybuilding purposes, the alternate exercises mentioned would be far more productive, without the injury risk.

Every exercise has its own, individual set of bio-mechanical circumstances. Understanding how to identify them, allows us to see where the benefit would be, and where the risk would be. We can then compare that to the benefit and risk of other exercises one could use for the same goal.

We should stop thinking of certain exercises as “magical”, as we have done with compound exercises. Rather, we should begin regarding every exercise as a set of bio-mechanical circumstances, that can be evaluated logically.

Chapter Fourteen

Momentum
& the Use of "Good Form"

When training for muscular development, the objective is to load a muscle with "resistance", and then cause the muscle to deliberately contract against that resistance until fatigued. This leads to muscle adaptation - an increase in its strength, size and endurance.

Momentum is a physics principle which typically reduces the load on a working muscle, during resistance exercise. People often use it subconsciously, in an effort to use more weight than the muscle can move by its own force, or to make the exercise easier For this reason, it is often referred to as "cheating" or "using bad form".

Using a weight that is technically "too heavy" for a particular exercise, and then using MOMENTUM (swinging / cheating) to lessen resistance to the working muscle, is impractical and inefficient.

The use of momentum, in training for muscular development, usually reduces potential benefit, increases the risk of injury and results in wasted energy.

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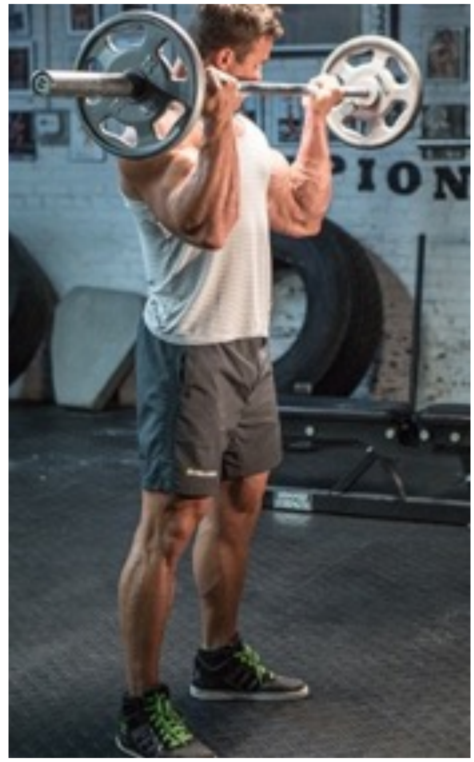
The two photos below show a man doing a *Standing Barbell Curl*, with fairly good form. He keeps his torso upright the entire time, from the beginning of the movement, until the end. The weight is being "lifted" (elbow flexion) entirely and exclusively by way of Biceps contraction. This is very efficient. Since there is no reduction of the load, there is no need to use more weight than the Biceps can handle.

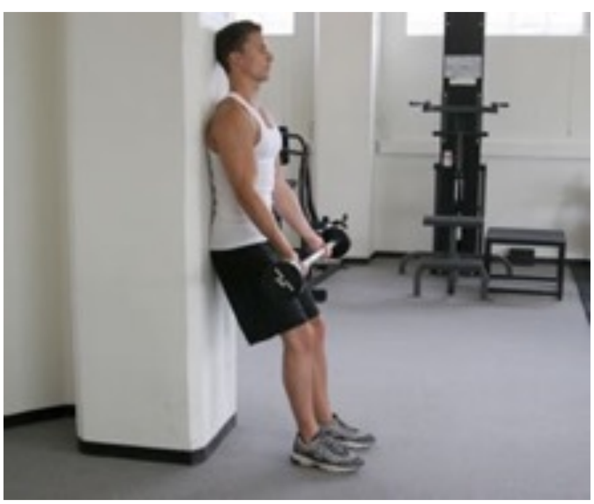
In the (vintage) photos below, we a young Arnold Schwarzenegger performing a *Standing Barbell Curl* with “terrible form”. He has 205 pounds on the bar - far more than his Biceps can actually handle - and then reduces the load on his Biceps by introducing this elaborate use of momentum. He throws his torso back, thereby propelling the weighted barbell upward. The result is that his Biceps get a lesser percentage of the load that is on the bar (notwithstanding normal “magnifying” physics, discussed in earlier chapters) - and his back unproductively loads a greater percentage of the weight.

This is a fairly dramatic example, above. We rarely see anyone in the gym using THIS much momentum, during their *Biceps Curls - although it does happen, from time to time*. More importantly, it serves as a good example of what the use of momentum in resistance exercise, looks like. Performing a Curl like this is very inefficient, because the Biceps are not working any harder than they would be if using less weight, without the momentum. Although the net load on the Biceps may be the same, extra energy is being spent that is **not** productive. Also, the potential risk of injury increases.

In Chapter 5 ("The Apex and the Base"), we discussed how when a weight is moving through the lower half of the sphere, there is a tendency to "swing". *Standing Barbell Curls* is one example of that. During this exercise, the barbell starts in the Base position (forearm parallel with resistance, below the pivot point) - which is neutral. From there, the resistance will increase as the forearm moves toward the perpendicular position.

It's very easy to "throw" a weight, when it's starting with zero resistance. And the temptation to initiate a heavy lift with a nudge is present, because one knows the resistance will feel heavier as the level moves upward. Subconsciously, we want to get a "running start", so to speak.

There are two very interesting aspects about this - the **<u>degree</u>** to which that "nudge" can reduce resistance, and how subconscious it is for us to initiate this type of movement with a "swing". Even a **modest** "swing" reduces the load to the Biceps, significantly. Both of these concepts can be tested, by first performing a **regular** Standing Barbell or Dumbbell Curl - and then doing it with your back up against a wall, which prevents any degree of torso swing. The comparison is very enlightening.



I am not necessarily recommending that this exercise be done this way on a regular basis. But this is a good test for identifying the tendency to initiate the movement with a torso swing (first forward, and then back), and also to realize how much of a difference it makes - in terms of load reduction. Almost everyone does it, to some degree. But a STRICT dumbbell or barbell curl is MUCH better.

A strict Barbell or Dumbbell Curl can be done without leaning against a wall, but it requires careful attention, on every single repetition to ensure one is not swinging the initiation of the reps. Of course, one is forced to use a lighter weight, when doing "strict" Curls - with no momentum - and that's perfectly okay. The Biceps will get just as much load, with less energy spent, and less "wear and tear" on the skeleton (bones and joints). But the ego must be put in check.

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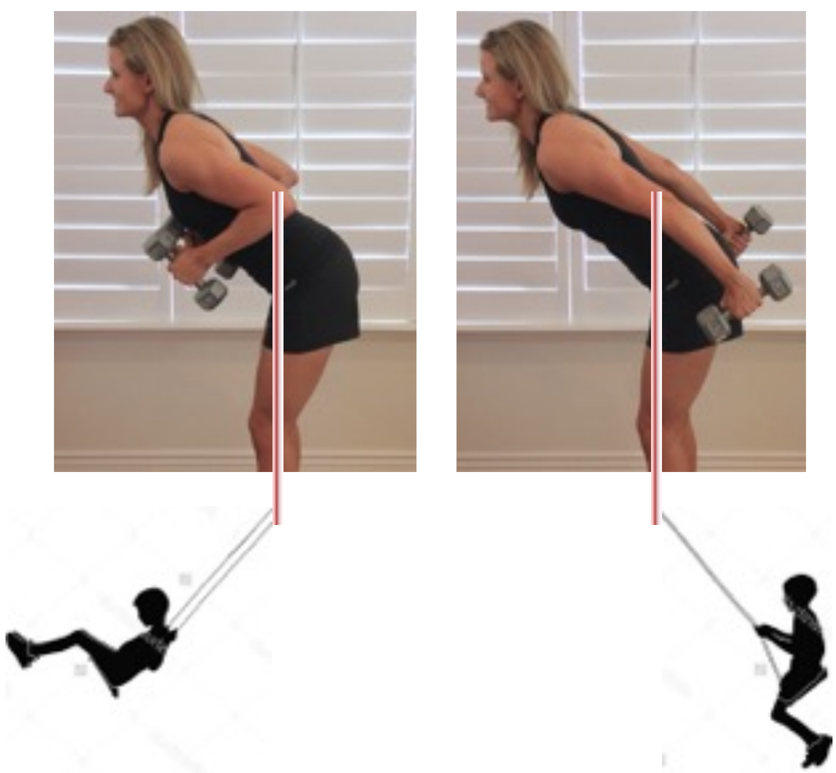
In Chapter 5, we looked at the example of the *Dumbbell Triceps Kickback*. This is also an example of using momentum, but a bit different than the *Standing Barbell Curl*.

Using momentum with the *Standing Barbell Curl* requires a sudden thrust-back of the torso, to initiate the propelling of the weight from the starting position. With *Triceps Kickback*, the weight is able to swing both ways, almost all by itself. This type of momentum is more like kids swinging in the park - back and forth, past the Base, each way.



The movement being produced during this type of *Triceps Kickback* may be more “swing” than deliberate muscle force. It could be as much as 60% “swing” (momentum) and only 40% muscle contraction. Plus, this “exercise” (if it can even be called that) also has the added problem of having the Base in the middle of the range of motion. Neither the Triceps nor the Biceps are loaded at that moment - despite the fact that that is an important part of the range of motion for both muscles. Both muscles NEED resistance at that point, during their respective exercises - but this one does not provide it. This is a complete waste of time.

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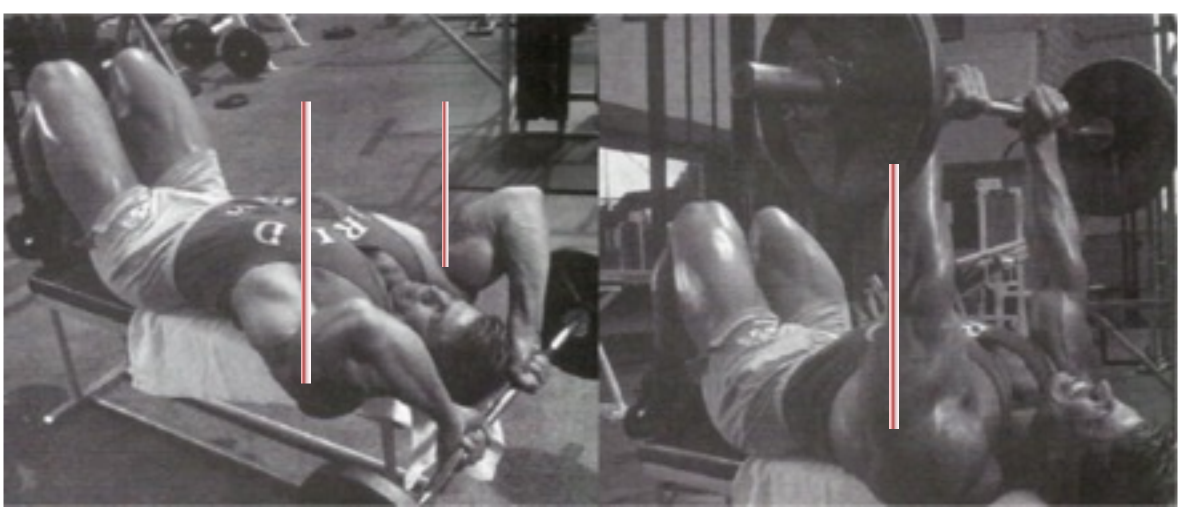
In the first set of photos below (blue shirt), we see what a *Supine Triceps Extension* looks like, using good form. Notice the elbows hardly move, from beginning to end.

In the follow set of photos, notice the “wind up” - how far past the shoulder line he brings his elbows, so that he can then “propel” the barbell upward by way of Latissimus thrust. Despite having more weight on the bar, his Triceps are only getting about **half** of it.



Why bother adding “extra” weight onto a bar, only to then subtract it from the Triceps, by “throwing” the bar upward with the Lats? This is not productive Latissimus work either, by the way. It’s just extra energy being spent, without it benefitting the Triceps.

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Below, we see a series of photos of a man doing a heavy “*Bent Over Barbell Row*” - using quite a bit of momentum.

He starts with an explosive “thrust” the second the bar leaves the ground - using mostly his Glutes and lower back. The bar then “travels” (sort of glides) upward, until gravity begins to slow down its trajectory. At that moment, the man quickly lowers his torso, so that the bar will touch his chest.

Of course, this is ridiculous as a muscle building effort. Even if he was using a “reasonable” weight, which allowed him to pull the bar up toward his chest without using momentum, it would be working his lower back and Posterior Deltoids **more** than his Lats and Middle Trapezius (as we discussed in “Opposite Position Loading”). But it is also obvious that having him drop his torso quickly, in order to have the bar touch is chest, is USELESS. It’s like pretending that he PULLED the bar up to his chest, by way of muscle force - when, in fact, he “feigned” it. Does he think the back muscles are fooled by this?

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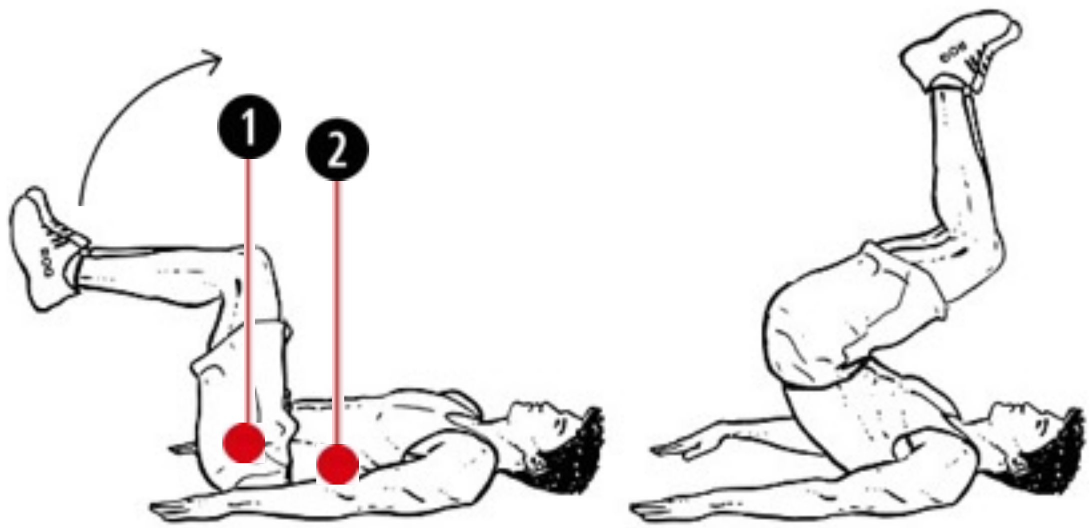
Combining Cheating Methods

(In this context, “cheating” simply refers to the deprivation of benefit - not to a person’s intentional avoidance to work diligently)

The exercise below - commonly referred to as “*Reverse Crunches*” - has several mechanical problems.

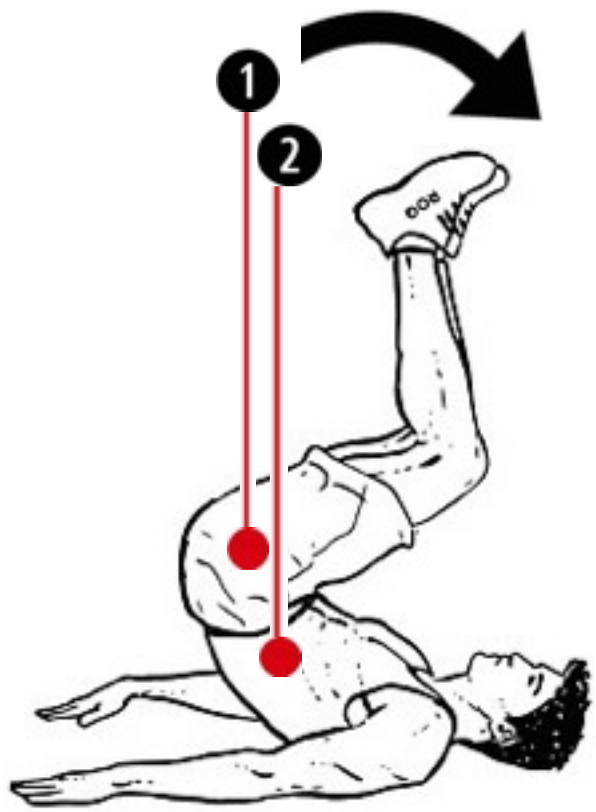


In the illustration above-left (the starting position), I've placed two red dots on the man - one on his hip joint and one on his mid-spine area. The hip joint is operating the femur and hip flexors, and the spinal pivot is operating the pelvis and the Rectus abdominis.

The exercise begins - as the black arrow indicates - with a semi circular upward "throw" of the legs. This movement - produced mostly by the hip flexors (90%), with a tiny amount of help by the Abs (10%) - initiates **momentum**.

Once the weight of the legs passes the Apex of the hip joint (#1), the legs begin to FALL in that direction - without needing any muscular force at all. Remember, in Chaper 2, we discussed what happens when the cart that was getting pushed up the hill, goes over the top and beginning free-falling down the other side of the hill.

Momentum, combined with the increasing distance of the legs from the line of the Apex line, PULLS the pelvis (hips) farther up. The arms (pushing downward) are also helping to push the lower spine upward. This creates the illusion that the Abs are doing the work.



In fact, contraction of the Abs is NOT producing this movement, **after the weight of the legs has moved beyond the Apex** of the hip joint and that of the spinal pivot. Momentum produces the movement on the **right** side of the red line (as observed from this perspective).

To make matters worse, people often then **PUSH** their legs upward - toward the ceiling - once their spine is fully “curled”. However, this is also NOT the abdominal muscle producing this movement. The Glutes are pushing the femurs upward - although the mere weight of the legs is hardly a challenge for the Glutes.

This exercise combines **momentum** and the **crossing-over of the Apex**, to deprive the target muscle (i.e., the Abs) of deliberate contraction. But - it must be acknowledged - the Abs cannot possibly participate much during **any kind** of Leg Raise movement, since the Rectus abdominis **does not connect to the legs**. The Abs only work as a spinal stabilizer when *Leg Raises* are being done. The hip flexors do almost all the work. Adding momentum simply makes this “bad” exercise even more useless.

Bouncing on a Stability Ball

Another kind of momentum that occurs with some regularity is bouncing on a Stability Ball while doing Ab Crunches. Of course, this doesn’t happen all the time. Sometimes these are done with good form, and when performed correctly, it’s a very good exercise.

However, occasionally we see a person who drops back so quickly that he (or she) literally bounces off the ball, which then propels them forward - without much need for contraction of the Rectus abdomens. It’s almost as if they’re bouncing off of a trampoline, which throws their torso forward, thereby minimizing the amount of work the Abs must do to. Instead of allowing their Abs to do 100% of the work, the momentum reduces that need to about 20% (depending on the degree of bounce, of course).

Needless to say, this is counterproductive. We could qualify is as “foolish”, except for the fact that some people seem to automatically seek the easiest way to do an exercise - without even being aware they’re doing it.

This bouncing is yet another way of creating momentum, which then reduces the amount of work the target muscle needs to do.

All of these (often subconsciously introduced) methods - explained above - result in the same outcome. They all produce momentum, which then reduces the resistance to the working muscle.

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Acceptable Applications of Momentum

(But still NOT useful for physique development training)

Olympic Lifting requires the use of momentum, because it is a demonstration of power, coordination and timing. It is comprised of two separate "lifts".

The "Clean and Jerk" and the "Snatch" both utilize an explosive "heave" to **send** the bar up to a particular height - either to shoulder height or overhead.

Below are the sequential stages of the "**Clean and Jerk**".

The lifter begins by pulling the weight from the floor, by way of force produced by the legs (Quads and Glutes). Then - at the point where the barbell is just past the knees - the torso is forcefully **thrown** up and back, and the legs are fully extended. This results in the barbell being "thrown" upward (momentum), to a height which then allows him to drop under it, into a squatting position. The lifter then stands (using Quad and Glute force) with the bar resting on his shoulders. Then, the lifter semi-squats (the "wind-up"), and then again "launches" the barbell up to a particular height - and again drops under the barbell, with a split stance. Finally, he brings both feet together, while holding the barbell overhead - until the indicator acknowledges the lift is "good".

Although it might appear that he's using his arms to “push” the barbell over his head, that’s actually not the case. Ultimately, he drops under the “thrown” barbell twice - once to get it to his shoulders, and again to get his arms underneath it. Most of the actual dynamic (deliberate) lifting is done by the Legs.

Below are the sequential stages of the “**Snatch**”.

The lift begins with an explosive upward “heave” of the bar (from the floor), produced primarily by the legs and lower back. This initial explosive thrust propels the barbell up to a height which then allows him to drop under it, arms straight and wide on the bar, into a Squatting position. This is done is one fluid motion. He then stands up with it, from the Squat position (using Glues, Quads and Adductors), and holds that position until the indicator signals that the lift is “good”.

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Both of these “lifts” involve the use of momentum. However, this type of weight lifting is not meant for physique development. In fact, it is a method of lifting that is completely of physique development training. Olympic Lifting seeks to maximize output (the amount of weight lifted), by using momentum and technique to minimize load. Training for muscular development is most efficiently done by maximizing a weight - making a lighter weight load a muscle more. This is done by way of levers that are more “active” and/or “longer”.

It should also be noted that because the goal of Olympic Lifting is to lift the heaviest amount of weight, there is always a tremendous risk of injury. These injuries could occur in the gym, while training for an event, or they could during the event.

People often make the assumption that any endeavor which involves the lifting of weights, leads to the same results. This is entirely false. Although the same physics principles apply, the exercises are different, and the way they are performed is very different. This leads to very different outcomes.

Magazines and other commercial sources play a role in this confusion. It behooves commercial operators to promote - and to have people engage in - a wide variety of “weight lifting” / strength training / fitness activities. But it misleads the consumer.

Olympic Lifting is NOT a “good” method of getting fit. Yes, one could say that any form of physical exertion helps a person “get fit” - to a degree. But not all activities work equally well, nor have equal injury risk.

Sports-specific training methods utilize exercises that are primarily designed to improve one’s performance in a particular sport. Those exercises may provide a small degree of cross-over benefit to someone pursuing fitness or muscular development goals - but they are far from the best approach.

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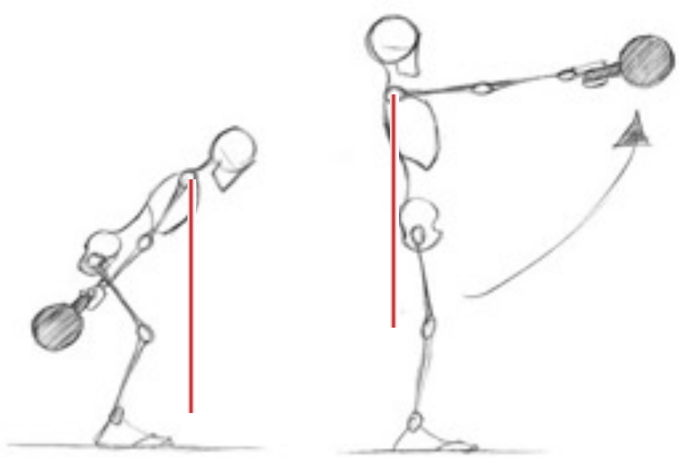
Kettle Bell Training

Some Kettle Bell exercises deliberately utilize momentum. The one pictured below - the “Kettle Bell Swing” - certainly does.

This is not necessarily “bad”, if one’s goal is simply calorie spending and general conditioning. For safety, it’s critically important that the spine to be held in the proper posture, during this exercise. It’s a fairly good cardiovascular exercise, involving mostly the Glutes, Quads and Lower Back.



But, if the goal is visible muscular development (i.e., maximum growth), this type of exercise will not produce results that are as good as exercises which require deliberate muscle contraction, against a directly opposing resistance.

In the exercise shown above, the Kettle Bell is propelled upward via a thrust (momentum) initiated by the legs and torso, along with a much lesser effort from the Deltoids. Once at the top, the Kettle Bell begins its downward trajectory. This downward fall of the Bell is coordinated with a descent into the Squat position - thereby adding some downward "centrifugal force" to the eccentric phase of the Squat.

Other Kettle Bell exercises, like the one (sequentially shown) below, focus on keeping the Bell balanced while maneuvering the body into different positions. Other Kettle Bell exercises are similar to standard Dumbbell exercises, or "Olympic Lifting" exercise - but with the "intentional imbalance" of a Bell (versus a balanced barbell or dumbbells).

Kettle Bell exercises can provide good general conditioning, but are not the type of exercises which are best for optimal physique development / bodybuilding.

There is also some degree of injury associated with this type of exercise. This includes getting banged up and bruised by the Bell colliding with the forearms, skin abrasion of the hands from the turning metal handle, and joint strain from the contortion which is sometimes required. For example, the body position above marked with the red dot, demonstrates some potential strain to both shoulder joints. An internet search of injuries associated with Kettle Bell training can corroborate this.

(Note: Higher rate of injury is not reason enough to avoid a particular activity. It's simply one of the factors which should be looked at when considering participation. The wise approach, in most cases, is weighing the "pros and cons" - the cost and benefits - of the activity in question.)

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Summary

Momentum can be produced, during an exercise, by an explosive "heave" - thereby essentially "throwing" a weight - in order to handle a weight that is heavier than that muscle can handle by way of its own deliberate contraction.

It can also be produced by swinging the weight, back and forth, from one side of the Base to the other.

It can also be produced by simply going beyond the Apex, and naively believing that the range of motion produced when a limb is "falling", is being caused by deliberate muscle contraction.

It can also be produced by bouncing on a springy surface - like a Stability Ball - in order to make the exercise easier.

In all these cases, the use of momentum reduces the load the working muscle is supposed to be lifting deliberately. This results in either having to use a heavier weight, unnecessarily - or allowing the target muscle to work less hard than it could be / should be. Both of these possibilities are counterproductive, when training for physique development.

Chapter Fifteen

BALANCE / CORE EXERCISES

in PHYSIQUE DEVELOPMENT TRAINING

The latest trend in fitness has people combining deliberate instability with traditional exercises. This is done, in theory, to improve "balance" and strengthen "the core". However, these concepts are not well understood by most participants, and the methods are not as productive as it would seem.

In this chapter, we'll explore the following questions:

Does adding "instability" during exercise, compromise the physique development benefits one would otherwise achieve?

Do these "unstable exercises" actually produce improvements in balance?

Does the average person need to improve his / her balance?

What is the "core"? And is "instability" the best way to strengthen it?

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One of the most common things we see in gyms these days, is people doing exercises **while** standing on one leg (instead of two legs), while sitting on a Stability Ball (instead of a bench), or while standing on an unstable surface, like a wobble board (instead of solid ground). In other words, people are doing **resistance exercises** while unstable.

Examples of this would include *Standing / One-Legged Dumbbell Curls* (below - left) and *Squats on a Bosu Ball* (below - right).

The **intention** behind this type of exercise modification is to improve balance, while simultaneously developing the physique and strengthening the body.

Let's examine where this latest goal fits in with historic trends.

Historically, these have been SEVEN primary goals associated with physical fitness.

1. Leanness (lower body fat)

2. Muscular Development (visible hypertrophy)

3. Muscle Strength

4. Muscular Endurance

5. Cardiovascular Endurance (heart and lung capacity)

6. Flexibility

7. Better Health (reduced cardiac risk factors, etc.)

The majority of people are usually very content having made ample progress toward these seven goals. The methods by which these goals are achieved are generally straightforward - notwithstanding common mistakes in biomechanics.

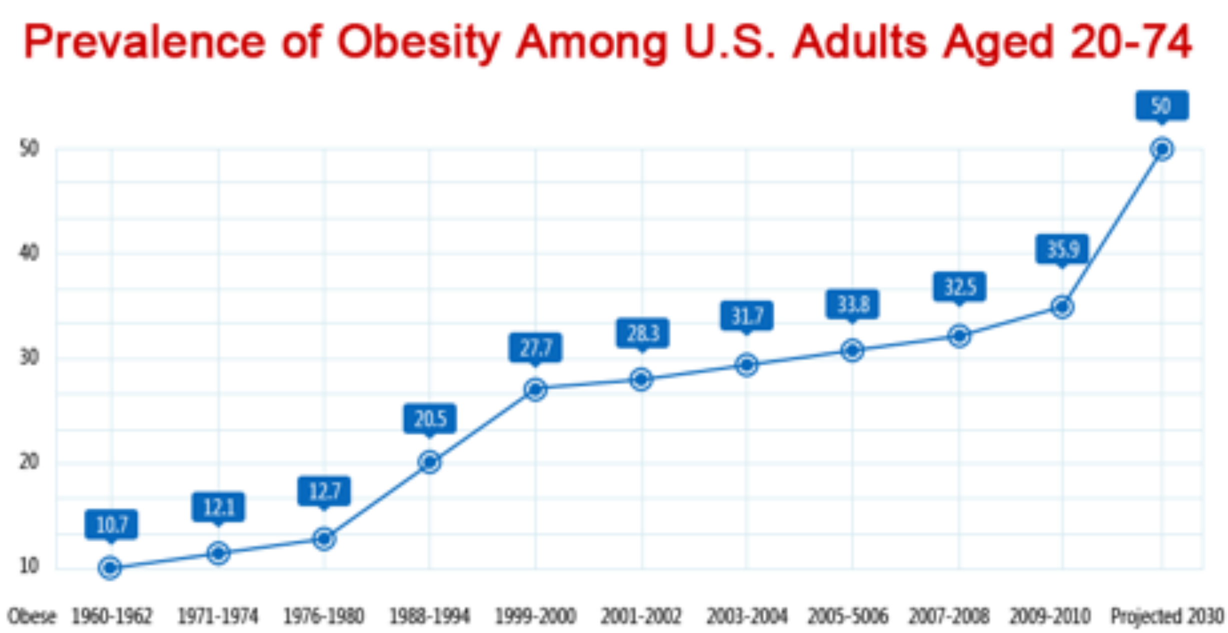
We do higher reps / lower weight for muscular **endurance,** and lower reps / heavier weight for muscle **strength** - both of which contribute to muscle **growth**. We do aerobic exercise for **cardiovascular** endurance, and - together with the anaerobic exercise and diet modifications - we achieve **leanness**. We stretch for **flexibility**.

Some people also play basketball or participate in some other sport, for athleticism and recreation.

These same activities also make us **healthier**. They improve our insulin sensitivity, reduce our risk of diabetes, lower our blood pressure, improve our VO2 max (ability to utilize oxygen), improve our bone density, improve our coordination, and provide us with a variety of other health benefits.

Since the early 1900s, millions of people have been gotten into outstanding physical condition using these types of activities. Even world class athletes have trained using these methods. However, beginning around 1999 (approximately), “balance” training started becoming popular. Today many people believe that “balance” training is **essential**. But this begs the question: If it’s “essential”, how could people have gotten into such good condition before it became popular?

Does “essential” refer to its effectiveness in terms of general conditioning (body fat loss, muscular development and/or cardiovascular and metabolic benefits), or in terms of its supposed improvement of people’s balance. Let’s briefly examine each of these.



Derived from NHANES data (http://www.cdc.gov/nchs/data/hestat/obesity_adult_09_10/obesity_adult_09_10.html#table1)

The chart above shows that - since 1960 - obesity rates in the United States have been steadily rising. As of the date of the study (2010), nearly 36% of all Americans qualified as “obese” (average of 30 pounds overweight). Currently, obesity is more prevalent than ever before, and it is projected to reach the 50% mark by the year 2030.

Ironically, revenues spent on “fitness products and services” has also been rising at approximately the same rate. Currently, there are more dollars spent annually on fitness products and services than ever before.

So, it would appear that “new products and services” - on which a growing amount of money is being spent - are not translating to fewer people being overweight. Also, those who are participating in fitness programs today are not necessarily in “better” shape than people who participated in fitness programs twenty or thirty years ago - as defined by traditional standards (body fat level, muscular development, cardiovascular risk factors, etc.).

Are we then to assume that “essential” refers to the improvement of balance?

If so, we need to first establish that “balance” was a **problem** before the advent of this type of exercise. Then, we would have to demonstrate that this type of exercise has made a significant impact on this problem, in order to qualify this type of exercise as “essential”.

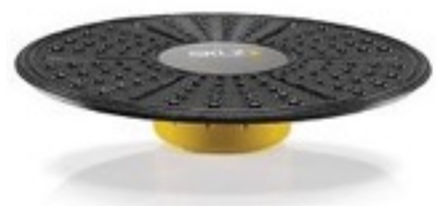
However, with the exception of people above the age of 70, few people ever complain about balance. The idea of “improving balance” might seem appealing, but most people under the age of 60 would not include it among their top five fitness goals.

Rather, it seems that the advent of balance exercise coincides with the use of “proprioception” training, which top level athletes and physical therapists began using in the late 90s. During that time, fitness magazines began running stories of top level competitive athletes (e.g., professional tennis players, professional boxers, etc.), explaining how they train for their respective sports.

People seem to love the idea of using the same training program as that of their favorite celebrity or professional athlete. Of course, the **performance** requirements of a top level tennis player or boxer would not necessarily coincide with the **fitness** requirements of the average consumer. And “celebrity” workouts reflect the latest trends, more than anything else. But the **marketing opportunities** were readily apparent.

Suddenly, a multitude of new “balance” products and services began popping up, targeting fitness consumers. They were marketed as either “*performance*” training or “*remedial balance”* training. Of course, this type of marketing was very appealing, and an entirely new category of “fitness” was created. The question is, “Does it work?”.





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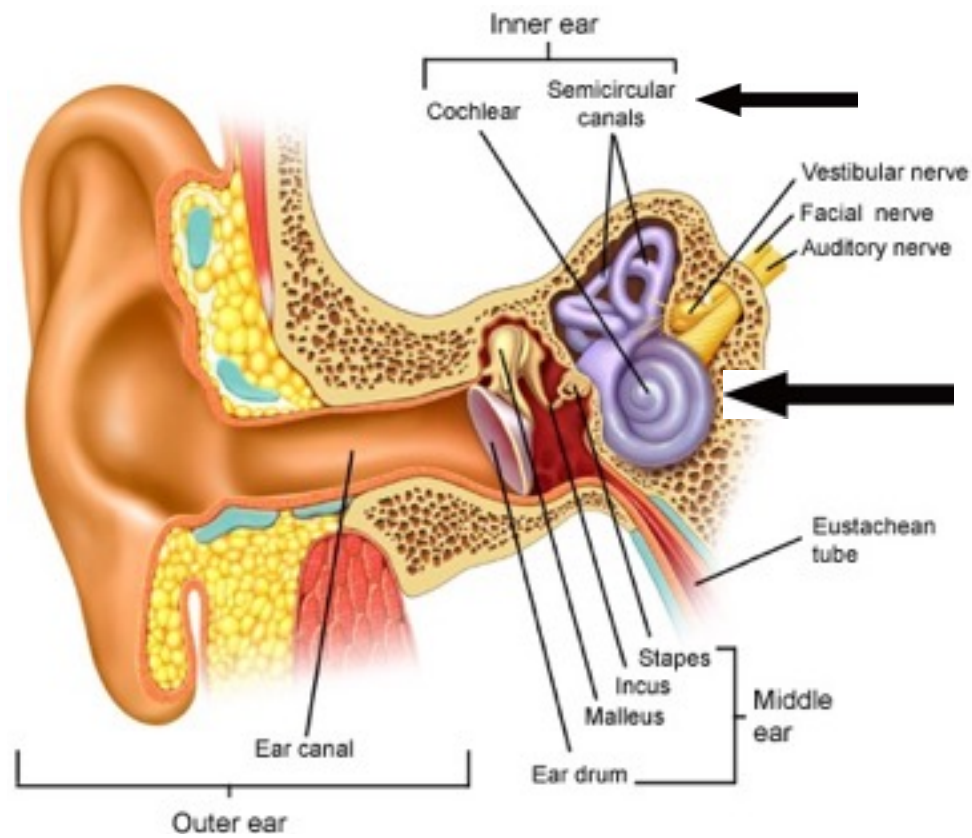
What is Balance ?

Technically speaking, balance is known as “**spacial orientation**”. It is our ability to sense the position of our body, relative to gravity. It allows us to know if we are leaning to the right or to the left…or forward or backward. It allows us to sense whether we are standing on a flat surface or on one that is slightly inclined. We are born with this sense of balance, because the mechanism is built into our anatomy. It involves our brain’s innate ability to receive and process information from the various balance sensors in our body.



The "vestibular system" in our inner-ears is our primary balance sensor. It is made up of tiny fluid-filled canals that are lined with microscopic hairs, plus a network of nerves and calcium crystals.

This inner-ear system, together with our eyes, plus the sensors on the bottoms of our feet and in our joints, allow us to know whether we are stable or off-balance.

Older people who begin having difficulty with their spacial orientation (usually over the age of 60) are typically experiencing a degradation of these balance sensors. This causes a person to feel as if they're about to fall, when they are actually stable - or to feel as if they are stable, when they are actually off balance. Sometimes it is accompanied by dizziness (i.e., "vertigo").

"Disequilibrium" (loss of balance) is usually caused by dysfunction in the inner-ear, or vision problems (cataracts, macular degeneration, glaucoma, etc.), or peripheral neuropathy (numbness in the legs and/or feet), or other neurological disorder. These are **medical** issues which need to be addressed by a neurologist or "otolaryngologist" - not a Personal Trainer.

What is Proprioception ?

Proprioception is the ability to sense and control what our various limbs are doing, without actually looking at them or thinking about them. For example, when we drive a car, we can maneuver the brake and gas pedal, without consciously thinking about them. We are able to apply just the right amount of pressure on each pedal, at the appropriate time, without much conscious thought - just as an experienced pianist or guitarist is able to play his/her instrument effortlessly.

This is only similar to "spacial orientation" in the sense that the brain receives signals from various sensors. However, proprioception is NOT a remedy for "Disequilibrium".

Proprioception is the **learning** of skills, such that they become automatic - like juggling. Improving our ability to Squat while on a Bosu Ball (and not falling off of it) is a <u>learned skill</u>, in which our central nervous system and muscles become increasingly familiar with the feeling of standing on a surface that is not solid. Specifically, the body is learning to respond to the fluctuations of the surface on which one is standing. So, when a person who has spent considerable time on a *Bosu Ball* stands on a **<u>solid</u>** surface, there is nothing to which their body can respond.

This explains why people who spend a considerable amount of time doing this type of exercise, do not notice much of a difference in their day-to-day "balance" - even when they have gotten very good at stabilizing themselves on unstable surfaces. Their body has only learned to compensate for the "wobbling" of a foundation on which they're standing - if and when the wobbling is present.

In fact, calling *One-Legged Exercises* or *Bosu Ball Exercises,* "<u>Balance</u> Training" is a misnomer. It should be called "**Proprioceptive** Training".

From a marketing perspective, there is quite a difference. Referring to unstable exercises as "**balance**" training suggests we are **fixing** an essential part of our physicality, which would otherwise be "broken". This naturally makes people feel **obligated** to do it. It might even be considered "<u>essential</u>".

On the other hand, referring to unstable exercises as "**skill learning**" would likely make people think twice about whether or not they should MIX that type of activity with normal exercise - given the potential compromise it creates. It might even make people doubt whether they're worth doing at all.

Learning to balance ourselves on a Stability Ball is a skill that will only manifest its **value** when attempting to perform daily activities that are **very similar** to balancing ourselves on a Stability Ball. That's not likely to happen very often. Like juggling balls, it's a skill which may or may not be worth the time to learn The question is whether juggling - or balancing oneself on a Stability Ball - should be **<u>combined</u>** with resistance exercise, simultaneously?

Physical Therapy

There are people with special circumstances which would make it beneficial for them to learn Proprioception of the feet and legs. This would include anyone with a neurological disorder, or people over the age of 70. In those cases, practicing standing or Squatting on unstable surfaces might be useful, although dancing and various other coordination drills would likely be better. But this is a specialized activity, and is appropriate primarily for people with a coordination / proprioception problems.

It should also be noted that proprioceptive learning is tedious and time consuming. It should be done daily, for best results. Thirty minutes per week is not likely enough to make a significant difference. Any type of learning - **especially tactile learning** - requires frequency and enough familiarity with the activity to produce an automatic response. Clearly, proprioceptive exercise is not for everyone.

Unfortunately, the fitness industry is promoting this type of activity for **everyone**, regardless of whether or not the person is experiencing a neurological disorder, is under the age of 70, or has expressed an interest in improving their ability to ride a skateboard. People with basic fitness goals are treated as if they have a balance "problem" that needs fixing. It has become "standard prescription" for the masses now.

A Common Scenario at the Gym

An overweight man in his 40s, joins a gym. He's been putting it off for a while, in part because he feels embarrassed about his current condition. He assumes most people in the gym will be more fit than him, and thinks he'll stand out as "the out-of-shape guy". But he has finally gotten the courage to join a gym, and is eager to get "lean, strong and healthy". Let's call him "Joe".

One day, when Joe is at the gym, he starts doing a set of *Supine Dumbbell Presses*, (shown below) for his Pectoral muscles, with a pair of 30 pound dumbbells. Joe is not entirely sure how this whole "fitness" thing works, but he knows that this exercise is good for his Pectorals, and figures it's a good place to start.

Along comes a trainer, who is employed by this particular gym. The trainer sees this "somewhat overweight man in his 40s", and correctly assumes that he's probably a little unsure about what he's doing. So, the trainer approaches Joe and says, **"would you like me to show you a better way of doing that?"**.

Joe is happy that this trainer is offering to help him, and automatically **assumes** that this trainer will (in fact) show him a "better way" of doing this exercise. Joe says, "yes!".

The trainer leads Joe to an area where the large "Stability Balls" are kept. Then he asks Joe to lie on the ball with the same 30 pound dumbbells he was previously using. Joe complies.

Joe lies back on the ball, and places both feet securely on the ground with wide foot stance. He then begins doing the same movement he was doing on the bench. Naturally, it feels a little less stable than it did when he was on the bench. The ball is a little bouncy and less solid than the flat bench. But it's not entirely uncomfortable, and it's still within Joe's ability to do the exercise with the same weights.

However, the trainer stops Joe, and tells him that he wants him to do it a bit differently. He asks Joe to raise one foot off the ground, and place the other foot in the center, on the floor. Joe follows this instruction, and quickly realizes that it's much less stable than it was with both feet on the ground. Before, there were three points of contact with the ground, so it was a "tripod". Now, there are only two points of contact with the ground, so it is a "bi-pod".

Joe realizes that in order to stay balanced, he needs to keep both dumbbells equally distant from the center of his torso, as he brings them down….just as a person walking a tight-rope would have to keep his balance bar equally balanced on both sides.

But the trainer now makes an additional request. He wants Joe to bring down **only the right arm**, while keeping the left arm up…..“and then switch”, the trainer says. Not knowing what to expect, and assuming the trainer is the “expert”, Joe complies with the instruction.

Almost immediately, Joe falls to the right side of the ball, because he had extended more weight to the right side of his body, than to the left side of his body. In essence, it would be the same as if the tight-rope walker had extended his balance bar too far to the right, creating “imbalance”. This would cause the tight-rope walker to also fall to his right.

Joe is now on the floor, feeling embarrassed that he was not able to stay on the ball. The trainer looks at Joe with an amused smirk, suggesting - ***“It looks like we’ve found a ‘problem’ with your BALANCE”***.

Joe suddenly becomes concerned that he’s in worse shape than he had thought. It seems he now has a **balance** problem, of which he was not aware !

The trainer helps Joe stand up and tells him to try again. Joe is determined to NOT fall off the ball, and will make every effort to prevent that from happening again. He exchanges his 30 pound dumbbells for 20 pound dumbbells, knowing this will reduce the odds of him falling off.

He gets back on the ball with the lighter weights. It’s a bit easier to keep his balance using the lighter weight, but not quite easy enough to **ensure** that he won't fall off again.

So he brings the weight (the dumbbell) closer to his side during the descent of the weight, rather than so far out to the side. This creates LESS imbalance (less magnification of the weight, due to a shorter lever on the right side), so Joe is able to stay on the ball.

After a few sets of this, Joe asks the trainer what the difference is between him doing the exercise on the bench, using both arms simultaneously - versus him doing it on a Stability Ball with one leg off the ground, and using only one arm at a time. The trainer replies, ***“Core”***.

Many people have heard of this concept, but are not exactly sure what it means. So Joe asks the trainer what it’s all about. The trainer tells Joe that the “core” is the ***“center of our body”***. He tells Joe that it ***“stabilizes our lower back and abdomen, and help us coordinate all of our movements - including balance”***. Of course, this is what the trainer has been taught by the industry.

The trainer further explains that ***"without a strong core, you have <u>nothing</u>"***. He then asks Joe the rhetorical question, ***"You wouldn't build a house on a weak foundation, would you?"*** - with a smug expression of "common sense".

(*Note: This is a ridiculous comparison. An architectural foundation is a flat slab of concrete, on which the weight of an entire house RESTS. The muscles of the midsection are important, but they do not serve the same purpose as an architectural slab of concrete.*)

"Wow", says Joe - thinking how lucky he was to have had this trainer help him discover this glaring "balance" problem he has. Almost immediately, Joe asks the trainer if he has any openings in his schedule for some "training sessions". Bingo - the trainer has a new client.

Being Lead Astray

Let's examine what actually happened here.

When Joe was doing his *Supine Dumbbell Press* on the flat bench, he was effectively working his Pectorals. He was using a pair of 30 pound dumbbells, and he was using "good form". He brought his humerus (upper arm bone) laterally, out to the side, with a vertical (neutral) forearm, so that the humerus represented a decent lever length. This is the proper mechanics for getting the most benefit to the target muscle - the Pectorals.

Later, when Joe experienced difficulty staying on the Stability Ball while using the 30-pound weights, he reduced the resistance to 20 pounds AND brought the lever in closer to his torso - which shortened the effective lever length of the humerus. Both of these "adjustments" **reduced** the resistance to his Pectorals.

Joe was then told that doing this **unstable** version of a *Supine Dumbbell Press* (i.e., on a Stability Ball, with one leg off the ground, and using only one arm at a time) would improve his **"core"**. In other words (although it may not have been voiced), the "trade-off" is that Joe would get less Pectoral benefit, but he would be rewarded for with benefits to his CORE, and improved balance.

In fact, by doing this "*Alternating Dumbbell Press, while on a Stability Ball, with one leg off the ground*", neither his Pectorals nor his "core" muscles would be worked as well as they could be, as compared with working each of these muscle groups separately. And the reason for this is PRECISELY **because** of the <u>instabilit</u>y of the exercise.

As was discovered when Joe first fell of the Stability Ball, bringing down a 30 pound dumbbell to one side with an extended arm will absolutely result in him falling of the ball. However, if Joe stood securely on the ground, and performed a straight arm *Torso Rotation* **with a Cable**, he would be able to load his torso rotation muscles with TWICE as much resistance - thereby working his "core" muscles much more effectively.

It's important to note that If the ground was covered with oil (while doing the above exercise), it would prevent a firm foot gripping on the ground. This would force one to use a lighter weight - which would then compromise the effectiveness to the target muscles. **Instability always limits the amount of weight that can be used**, which always compromises the loading of target muscles.

If John performed his normal, *Supine Bench Dumbbell Press*, using his original 30 pound weights and his normal lever length arm (humerus), he'd be able to work his Pectorals much more effectively, as compared with having to balance himself on the Stability Ball.

Trying to do both exercises, simultaneously, compromises both. Some people may think it's a clever way to exercise because (they mistakenly believe) it allows both muscle groups to be worked very well, simultaneously. In fact, it does NOT work each muscle group **as well** as each could be worked separately.

The fact that it's challenging might make it fun (like a game). Juggling is also challenging, as it "tight rope walking", but neither of these activities allows one to effectively build muscle. Activities that are fun, or "challenging" - while doing resistance exercise - do not necessarily translate to effectiveness for muscle hypertrophy.

So - in fact - the trainer did <u>**not**</u> show Joe a "better way" to do that exercise. Instead, he lead Joe to believe that he has a problem to correct before he can proceed with this goal of building muscle, losing fat, developing endurance and becoming healthier. And this is simply not true.

It's not that the trainer is corrupt, deceptive or unscrupulous. A trainer simply wants to earn a living, and wants to do his (or her) job well. However, the fitness industry has convinced the trainer that doing his job “well” (these days) requires focusing on “balance” and “core”. This creates a wider variety of activities, services, equipment and gadgets - all of which are good for the fitness BUSINESS.

Teaching this type of exercise is good for health clubs; good for the fitness associations which host workshops and conventions; good for manufacturers of products (which pay for advertising); good for publishers of magazines; good for presenters and for trainers. But it’s not necessarily good for all consumers, as demonstrated by the statistics.

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Risk of Injury

Any time there is instability, there is less “security” - and this is made worse when the resistance being used is significant. When performing UNSTABLE resistance exercise, there is a direct correlation between the amount of weight one is using, and the potential for injury.

In the photo below, we see a man performing a Barbell Squat, using 135 pounds, while balancing himself on a Stability Ball. This is an extremely dangerous (i.e., foolish) endeavor.

He compromising the amount of weight he'd be able to use if he were Squatting on the solid ground, so he's getting less load on his target muscles (Quads and Glutes), and therefore less "muscle building" benefit.

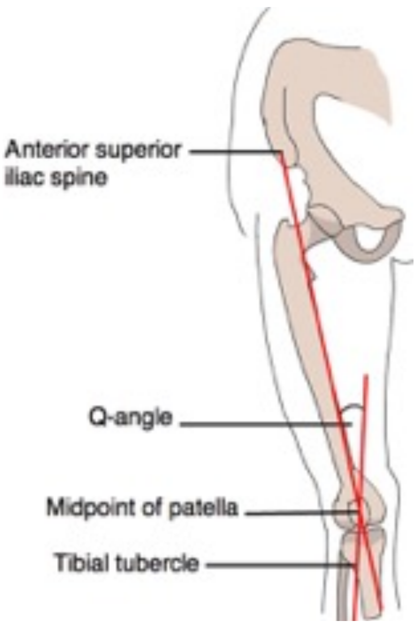
He is specifically "learning" how to coordinate a Squat movement while on an unstable foundation. However, an unexpected slip of a foot could cause him to twist his torso dramatically and suddenly (in an effort to prevent a fall to the ground), which could injure a spinal disc, a knee, shoulder, ankle, etc.. And the skill he is learning here has practically no use whatsoever in daily life.

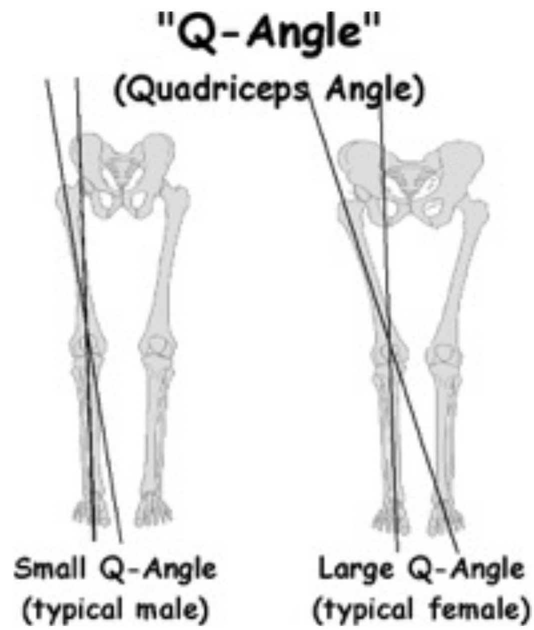
Granted, this type of "balance training" is not as common as "Squats on a Bosu Ball" with no additional weight, and it has a higher risk of injury than most other "balance" exercises. However, all of these have some degree of risk, which must then be compared to the potential benefits of the exercise.

Something as seemingly innocuous as just "Standing on One Leg" - whether while Curling a pair of dumbbells or not - has a degree of risk. In order to compensate for the fact that only one leg is supporting the body weight, we shift the center of our body mass directly over the one foot that is on the ground.

This causes the supporting leg to not be vertical. In the illustration above, we see the left leg supporting the weight of the body, and the right foot elevated off the ground. The arrow shows how the foot has been placed directly under the center of the body mass. If this were not done, the person would fall toward the side of the elevated leg.

However, this shifting of the body mass causes in increase in the “Q Angle” of the hip and knee.

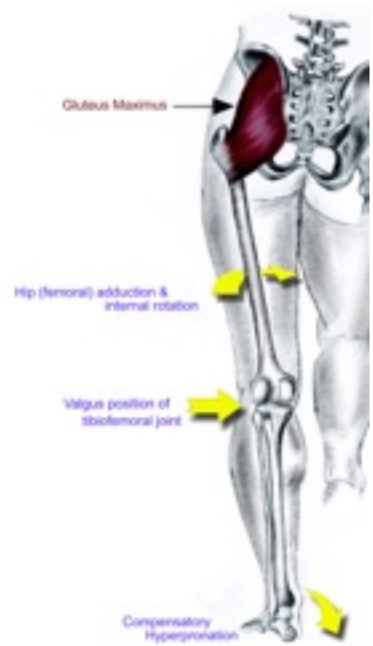




The “Q Angle” is the difference between the line that follows upward from the Tibia (lower leg bone) and the line that follows from the patella (knee) toward origin of the Quadriceps. The wider the hips, the more severe our “Q Angle” is, even when standing on both legs. Since women naturally have wider hips than men, they tend to have a more severe Q Angle.

When we stand on one leg, we exacerbate the Q Angle, which then has the potential to strain the hip joint and/or the knee. As the Quadriceps contracts, it pulls the Quadriceps insertion toward its origin, which tends to pull the patella (knee cap) laterally, creating potential knee strain.

Increasing the Q Angle also tends to create a compensatory shifting of the lower leg, laterally (outward). This is called “Valgus” (illustration below). Some people have “Genu Valgus” (genetically determined), even when then stand on two legs. But - in either case (genetic or not) - it’s exacerbated when standing on one leg.



So, simply standing on one leg, repeatedly, three times per week, has some potential to strain the hips and knees - and the degree of risk increases when resistance is added. The greater the resistance, the higher the risk of strain.

Of course, not everyone's hips are the same width, and not everyone's knees compensate by creating Valgus (bending outward). Therefore, everyone has a different degree of risk. But it does add yet another "cost / benefit" factor when considering whether to do One Legged exercise.

Logically speaking, it makes more sense to do our resistance exercises while standing securely on two legs. This would eliminate the potential strain of increasing the "Q Angle", as well as the compensatory Valgus at the knee. It would also allow us to use a higher resistance without concern of tipping over.

One Legged Squat

(also known as "Pistol Squats")

It's common to see people performing this type of Squat in the gym these days. If one were to ask a trainer what the difference is between doing them with one leg, versus two legs, you'll be told that it helps with balance, and also doubles the load on the working leg.

We now know that it does not help with “balance” - as per the technical definition of balance. It is another form of Proprioceptive Training, so it familiarizes a person with that movement, thereby allowing them to “learn” how to control it.

Again, this is a skill which is not likely to have much practical application in daily life. Yes - it does double the load on the working leg. But one could easily do a two-legged exercise with resistance, and achieve the same result. That leaves the question of risk.

Below, we see a front and back view of a *One Legged Squat*. As you can see, the lower we descend, the more drastic the Q Angle becomes, as well as the tendency to create Valgus with the knee / tibia.

In addition to the Q Angle / Valgus compensation that occurs, there is also the issue of the spine. Whereas it's fairly easy to keep a neutral spine when doing *Two Legged Squats*, it is much more difficult to do so when doing *One Legged Squats*.

So - again - this adds yet another factor to consider, because of the risk of injury or strain.

This begs the question: “Why spend the extra energy, and increase the risk of injury, if all we are doing is “Proprioceptive” exercise, which teaches us a skill for which we don’t likely have a practical application? One Legged Squats simply do not provide much of a useful benefit, and they typically have a higher injury risk.

A better result could be achieved - in terms of traditional “fitness” benefits - by doing a standard Two Legged Squat, for higher reps. Or - if that’s too “easy” - one could do “Jump Squats”. And if that’s still too easy, one could hold a pair of dumbbells in each hand, or use a slightly frontward pulling Cable. In all of these cases, the demand on the working muscles is increased WITHOUT creating the misalignment that occurs with *One Legged Squats*.

(Note: Jump Squats should not be done while holding weights.)

It should be noted that the typical “reasons” why people opt to do *One Legged Squats* are usually not based on sound logic, nor because of a better bio-mechanical value. It is usually based on the misguided belief that there will be an improvement in our ability to balance better…or because it’s the current trend. People tend to want to keep up with the latest trend, so as to not be “left out”.

Also, people (especially men) tend to be competitive. We tend to be enchanted by the idea of being able to perform a challenging task which few others can perform. We often get together with our buddies at the gym, and see who can “succeed” at that task - and who will “fail”. We seek the accolades we’ll get if we “succeed”, and we try to avoid the “shame” of failing. We also dole out the shame to others who “fail”. That’s all part of the “fun”.

This is fine, if one’s goal is simply to have a fun workout. There’s nothing “wrong” with a person using their workout as a game or a social experience. However, for those who are serious about pursuing muscular development - who want maximum benefit and want to avoid unnecessary risk of injury, the bio-mechanical factors related to unstable exercise, should be considered.

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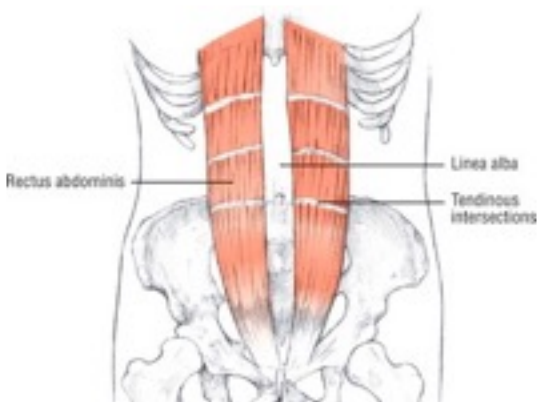
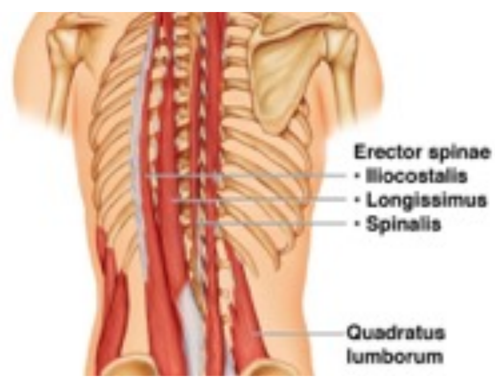
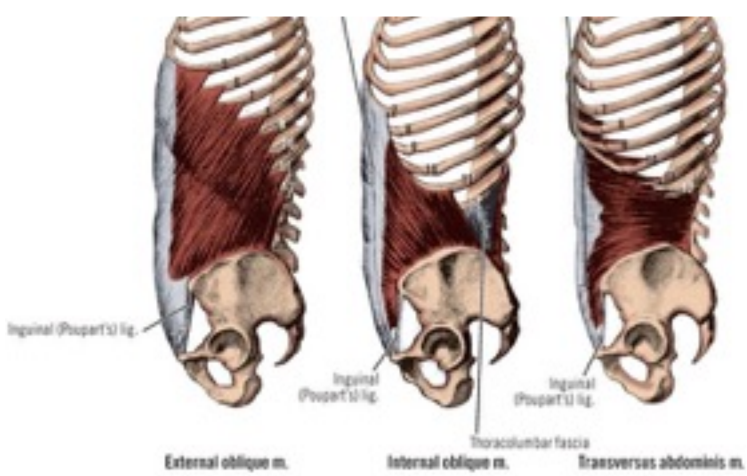
What is the “Core” ?

The “core” simply refers to the group of muscles that surround our midsection. They include the Rectus Abdominis, the Erector Spinae, the Internal / External Obliques and the Transverse Abdominis - primarily. These are the muscles that bend our torso forward, backward, side-to-side, and cause rotation of the torso. They are important for posture and for spinal protection, and they are involved in most bodily movements.







These muscles will be thoroughly discussed in the Anatomy section of this book - specifically, Chapters 23 and 24.

Mention of the “Core” is included in **this** chapter ONLY because it is frequently included in the conversation about “balance” - but unreasonably so. In fact, the term “core” is grossly over-used.

In the theoretical “scenario” described above - the one about “Joe” and the trainer - I showed how the issue of staying on the ball (mistakenly referred to as “balance training”) invoked the “core”.

People often say that, “*Squats are good for the core*”; “*Tight-rope-walking is good for the core*”; “*Standing on one leg is good for the core*”. But this is all nonsense.

Exercises that are truly good for the “core” are exercises that **work** the abs, lower back and obliques. Everything else just “involves” these muscles peripherally. The core muscles have no more to do with “balance” than does having healthy feet. They certainly have less to do with balance than having good “spacial orientation” - which essentially means a good “vestibular system” (inner-ear) / eyes / neurological system.

If one regularly performs exercises for the abs, lower back and obliques, they will have a strong core. There is no need to do off-balance / unstable exercise, in order to have a strong core.

Playing tennis or basketball, dancing, etc., will “proprioceptively” coordinate the muscles of the body - which involves the core muscles. The more we do activities like these, the better we get at those activities. But playing basketball and dancing are not a replacement for actually “working” the abs, lower back and obliques - with resistance.

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Summary

People who have a legitimate problem with balance (“spacial orientation”) likely have a problem with their inner-ear / eyes / neurological system, and should seek help from a qualified medical professional.

Performing exercise while standing, lying or sitting on an unstable foundation will not “fix” a balance problem that is caused by an inner-ear / eye / neurological system dysfunction.

Exercises performed on an unstable foundation improve “proprioceptive” skills associated with that specific exercise, or activities very similar to that specific exercise.

Performing an exercise on an unstable foundation compromise one's ability to perform that exercise in a way that maximizes the muscular development benefits of that exercise.

Unstable exercises often have a higher degree of injury risk, as compared with stable exercises. When unstable exercises are performed with additional weight (beyond body weight), the injury risk usually increases.

Activities involving movement of the whole body - like dancing - tend to be more productive for the improvement of coordination, than activities where one is simply standing on one leg, or "balancing" on a Wobble Board.

"Core" exercises are not synonymous with "balance" (proprioception) exercise. Although muscles of the "core" are peripherally involved in many activities, exercises that are "good for the core" should be ones that follow the same bio-mechanical principles applied to all the other skeletal muscles - including "range of motion" and "opposing resistance".

If one feels that there is a benefit to be gained by incorporating proprioceptive exercise, it should ideally be done separately from standard resistance exercise, which is intended for muscular development. The idea that combining the two "saves" time, is not entirely accurate. When performing them simultaneously, the effectiveness of both is compromised, and the risk of injury greatly increases.

Chapter Sixteen

"Cross-Education"
& the Benefit of Uni-lateral Exercise

"Cross-education" is a neurophysiological characteristic whereby an adaptive exercise benefit crosses over to an untrained limb following unilateral resistance exercise with the opposite, contralateral limb. The benefits include improvements in strength, muscle size, range of motion and coordination.

Contralateral benefit caused by unilateral exercise proves that there are neurological adaptations to resistance exercise, in addition to the more obvious muscle growth caused by direct (Ipsilateral) resistance exercise.

It also suggests that performing uni-lateral exercise provides benefits beyond those achieved with bi-lateral exercise.

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In 1894, Edward Wheeler Scripture (1864 - 1945) - an American psychologist, physician and speech scientist - published a paper in the Yale Psychology Laboratory, called "On the Education of Muscular Control and Power", in which he revealed this interesting phenomenon.

Dr. Scripture reviewed an earlier study conducted by a German scientist named *Alfred Wilhelm Volkmann* (1801 - 1877). In that study, Volkmann had demonstrated that touch sensitivity would improve over time, with repeated training of one hand. But, more importantly, he also demonstrated that the **untrained** hand improved its touch sensitivity, to a lesser degree.

Curious about this interesting "cross-over" improvement of touch sensitivity training, and aware of other studies demonstrating increases of strength with repeated exposure to exercise, Dr. Scripture conducted his own study, to see if these two types of benefits could be combined.

He had **two** people perform **two different unilateral** exercises - one designed to improve strength and the other designed to improve skill (accuracy with speed). The person performing the unilateral **strength training** increased her strength in the trained arm by 70%, but also in the UN-trained arm by 40%. The person performing the unilateral **skill training** improved her accuracy in the trained arm by 45%, but also in the UN-trained arm by 25%. These were the degrees of benefit he reported, although subsequent studies have found differing degrees of cross-over benefits.

In a 2007 article by authors *Michael Lee* and *Timothy J. Carroll* called *"Cross Eduction: Possible Mechanisms for Contralateral Effects of Unilateral Resistance Training"*, they reported a magnitude of 7.8% (average) strength improvement to the untrained limb, with a 35% (average) strength improvement in the Ipsilateral (trained) limb. (1)

A study conducted in 1997 investigated the concept of "cross-eduction", in which the strength level of both (right and left) Quadriceps of volunteers was measured before the experiment. Then, a 12-week program of progressive resistance exercise was performed, using **only** the **left** leg. At the conclusion of the 12 weeks, the authors reported a "significant" strength increase in the un-exercised (**right**) Quadriceps of the volunteers. (2)

Two other studies, published in The ***Journal of Exercise Science and Fitness***, reported strength gains in an un-trained limb that ranged between 5% and 15% of those achieved in the trained limb - depending on which limb is "dominant". Cross Education is more pronounced when the dominant limb is the one that's doing the uni-lateral exercise. (3)

In addition to <u>**strength**</u> increases transferring from one limb to the contralateral limb of the opposite side, one study found there is also a crossover enhancement of **endurance**. That study demonstrated that there was enhanced activation of the genes that support endurance, in the <u>untrained</u> contralateral limb, for several days after exercising the opposing Ipsilateral limb. (4)

"Cross Education" sometimes goes by another name - "***Neural Integration of Interlimb Coordination***". This is the name used by researchers Howard and Enoka in their study, and makes more obvious the apparent connection between uni-lateral exercise, and coordination / skill learning. (5)

Most of the research seems to focus on "contralateral" benefit (from one SIDE of the body to the other side of the body, in the **opposing limb**). However, it appears there may also be some cross-over benefit from UPPER BODY to LOWER BODY, and vice versa. This was reported by the authors of a June 2105 in the *"Journal of Sports Science and Medicine"* entitled*, "Unilateral Plantar Flexors Static-Stretching Effects on Ipsilateral and Contralateral Jump Measures"*. (6)

Of course, the amount of benefit an un-exercised (contralateral) muscle receives will always be significantly less than that which is received by the directly exercised (Ipsilateral) muscle. But even a 5% benefit is extremely interesting and very useful, and several reports claim a much greater percentage of benefit.

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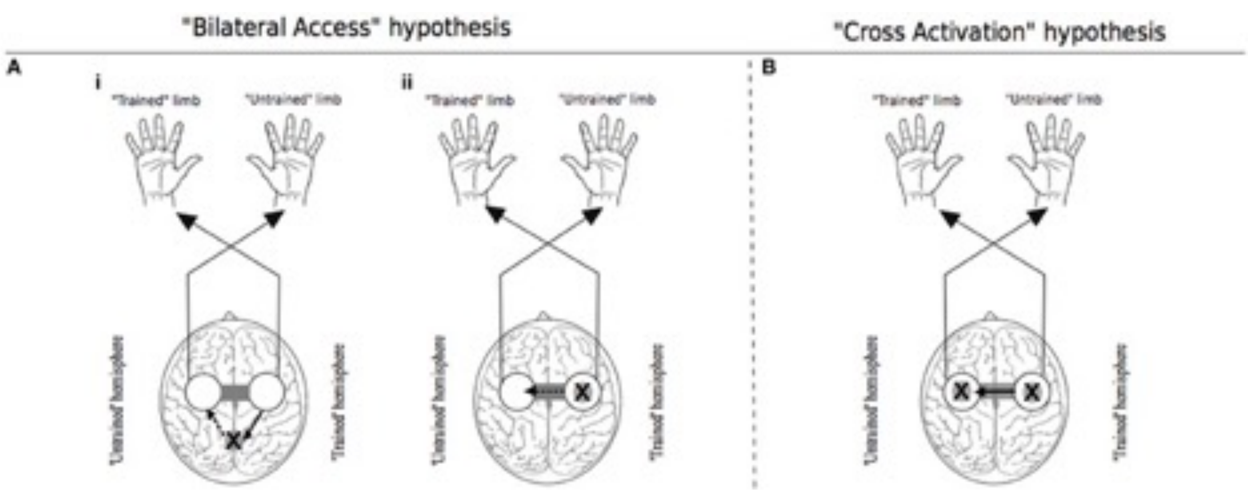
Mechanism

The illustration below shows the neurological pathways by which this might occur. Although researches are not sure of the mechanism, it seems clear that "cross-education" involves the brain and central nervous system. It's also clear that there is a neurological component in all resistance exercise, but especially in **unilateral** exercise.



In a June 2105 article in "Arbeitsphysiologie" (European Journal of Applied Physiology) entitled, *"Ipsilateral resistance exercise prevents exercise-induced central sensitization in the contralateral limb: a randomized controlled trial"*, the author described these two theories.

"Two potential neural mechanisms have been suggested as potential explanations (for how "cross-education" occurs):

(1) Enhanced efficacy of the spinal and/or cortical motor pathways of the contralateral limb and

(2) Facilitated accessibility of the contralateral limb to the brain area responsible for motor control (Carroll et al. 2006; Lee and Carroll 2007).

According to evolutionary biologists, every bit of our design stems from an evolutionary need for survival. Over millennia, our survival has relied on our ability to adapt to environmental conditions. Cross-education seems to have evolved as an evolutionary aid for survival.

There is no doubt that symmetrical functionality is "better" than one-sided functionality, and this would bolster the argument that evolutionary survival was the reason for its development. It also gives support to the theory that humans find other humans "attractive" largely on the basis of visible symmetry. People who are visibly symmetrical are probably more functionally symmetrical, and that would translate to a person being better able to to survive, to provide and to pass on those genes.

This might also explain the discrepancy, in terms of the differing **percentages** of cross-over benefits observed by the researches who conducted the various studies. It's possible that the people who experienced a greater percentage of cross-over benefit, were those who were more genetically inclined for survival - more robust. Those who are less genetically inclined to adapt to challenging situations may be the ones who experience a lesser percentage of cross-over benefit. However, it seems everyone experiences a degree of contralateral benefit from unilateral exercise.

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Applications of Cross-Education

The most obvious application of this principle - in modern society - would be the **rehabilitation** of an injured limb, or in case of a stroke. After a limb injury or a stroke, a person might be inclined to stop exercising altogether. However, the better option is to **continue** (or start) exercising all the limbs and muscles that are not injured or otherwise disabled.

A person can reasonably expect to get some degree of benefit in the disabled limbs, by exercising the "still-fully-functional" limbs. Also, continuing to exercise the healthy limbs will improve one's overall systemic health, as well as their psychological well-being.

Some people worry that if they continue exercising the stronger limb - while the injured / immobilized limb performs no exercise - the stronger limb will get so far ahead of the disabled limb, that the disabled limb will never catch up. This is inaccurate.

The limb that is stronger will **not** continue getting stronger and stronger, endlessly. It will reach a genetically determined limit, at which point its progress will either slow considerably, or stop entirely. When the weaker side resumes exercise, its progress will be much faster than normal, because it has more strength potential ahead. Once the injured limb resumes exercise, the difference between the two limbs (in terms of size and strength) will eventually return to the pre-injury difference. All opposing limbs are slightly different than each other, regardless of whether or not an injury has occurred.

In a previous experience, I had proven to myself that the size and strength of an injured limb eventually "catches up" to that of the UN-injured limb, once regular exercise resumes.

I tore my left Biceps tendon in 1998, after which I had it surgically repaired. I was not able to use my left arm for approximately four weeks following the surgery. I was instructed to keep it in a sling. During that time, I continued working my right arm as normal. I also exercised all the other muscle groups, to the degree that I could - having my left arm in a sling.

After the initial four weeks, my left arm was able to begin LIGHT exercise. I started with ONE POUND curls - and even that was painful. However, I soon proceeded to 3 pounds, then 5 pounds, and so on. Within five months, my left arm had returned to approximately 90% of its normal size and strength. Within a year, it was impossible to see any difference whatsoever between my two arms. 18 months later, I was competing again.

The photo above-left was taken immediately after my Biceps surgery (re-attached Biceps tendon). The photo above-right was taken during the 2000 Los Angeles Championship…..approximately 18 months later.

Compensation for a Weaker Side

The vast majority of people have have some degree of imbalance (strength and strength) from one side to the other, even without having experienced in injury. Sometimes it's not necessarily the dominant side that's stronger, for some reason.

We might have a stronger **left** Biceps, and a stronger **right** Triceps. Also, if one has had a previous injury, there may be a slight, but permanent, weakness on that side.

The good news is that - with Cross Education - we can have confidence that some of the benefits from the stronger side will cross over to the weaker side. In fact, the research shows that the percentage of contralateral benefit is usually higher to the weaker limb, when it's the stronger limb doing the work. That would make sense, of course - given the apparent tendency of the human organism to seek symmetry.

This allows us to use whatever weight is **manageable** for each side, even if we must use a lighter weight on the weaker side. This is advisable, in fact. It would not be wise to use a weight that is "too heavy" for the weaker side, simply because that is the weight we're using on the stronger side. We tend to do that, because we're afraid we'll perpetuate or exacerbate the asymmetry. However, using a weight that is too heavy for the weaker side will encourage bad form, and increase the risk of injury.

Defining "Unilateral"

The studies that have been done in regard to Cross Education demonstrate that performing an exercise with one limb - independently from the opposite limb - has a benefit beyond that which is experienced by the working limb.

If we are able to get a 5% to 10% cross-over "bonus" benefit (to the opposing limb), simply by having each limb working independently, it is likely that we'd get more muscle hypertrophy benefit if we followed this same exercise protocol during regular workouts.

The Cross-Education studies that were done involved the use of **only one limb**, because the point of the study was to measure the benefit that could be achieved by the <u>INACTIVE</u> limb. This was referred to as "unilateral" exercise.

Historically, "**uni-lateral exercise**" has been defined as "one limb working <u>at a time</u>". However, the reason "unilateral" **exercise** has value is because of "independence". If we perform a dumbbell curl with the right arm, it is working **independently** of the left arm, even if the left arm is also exercising.

In fact, the term “unilateral” should be equated with “independence” - rather than by “timing”. All exercises, during which each limb is working independently, could (and should) be called “unilateral”. This is true even if both limbs are working at the same time. Two dumbbells, being curled simultaneously, would still be “unilateral”.

Consider two bicycle riders, riding side-by-side (below-left). Their paths and timing may be coinciding, but each is working separately.

Now consider two bicyclists riding “tandem” (above-right). They are sharing the same “instrument”. They are both **contributing** to the movement of that instrument; neither is **solely** responsible for the movement of that instrument; and each of their actions affects the other contributor (rider), to a degree. They are **not** working entirely independently. This would be like a person’s two arms contributing to the movement of a single **barbell**.

The term **“bilateral”** has typically been used to describe an exercise where a person is using two arms, each with its own separate dumbbell, but simultaneously. However, the term “bilateral” should **not** be defined ONLY as “both arms working simultaneously”, because it does not stipulate whether they are working independently of each other.

A *Standing Dumbbell Curl* does not have the exact same mechanical / neurological effect on the Biceps as does a *Standing Barbell Curl* - so they should not BOTH be called “bi-lateral”. The “Cross Education” studies suggest that there is benefit to having limbs working independently, so the description of the exercise needs to identify whether there is “independence” or not.

“Bilateral” should be defined as *“Both limbs contributing to the movement of a singular instrument.”*

“Unilateral” should be defined as *“A limb working independent of its opposing limb, regardless of the timing of the two limbs.”*

In fact, there are three types of “unilateral” (independent limb) exercise.

Isolated Unilateral Exercise: Only one limb working

Alternating Unilateral Exercise: Two limbs working independently, alternately

Simultaneous Unilateral Exercise: Two limbs working independently, simultaneously

I propose we refer to these types of Unilateral (independent limb) exercise as follows:

“Iso-Unilateral Exercise”

“Alter-Unilateral Exercise”

“Simul-Unilateral Exercise”

All three types of unilateral exercise share in common the fact that a limb works independent of the other. The only difference is timing.

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When To Use Which

There are circumstances - certain muscle groups and certain exercises - during which each of the above versions of a “Unilateral” is **ideal**.

For example, in the exercise below, I am doing a “***One Arm Side Cable Raise***”. This is a good exercise because it provides excellent “early phase loading” of the Lateral Deltoid. This exercise is BEST performed one arm at a time - “Isolated Unilateral”.

There are several reasons why this exercise is BEST performed this way. It would be difficult to set up two pulleys at this exact height, but in opposing directions. Even if one could arrange it, the cable hands would likely collide in the middle. During an exercise like this, it’s extremely effective to focus ALL of one’s attention on movement to the right, or to the left - rather than trying to divide the focus in two opposite directions.

In the exercise below - *“Standing Alternate Cable Curls”* - I am using both arms, independently but alternately. This type of unilateral exercise would be considered an “Alternating Unilateral” exercise.

Again, there are several reasons why THIS exercise is best performed this way. Doing both arms at the same time (simultaneously) would load up the lower back 50% more than curling each arm alternately. Of course, this matters most when the weight being used is “heavy”.

Also, when doing this exercise, it helps considerably to lean toward the side that’s working. This allows better alignment between the direction of resistance and the movement of the humerus (moving directly toward the shoulder, where the Biceps origins are). Using dumbbells, for Standing (or Seated) Curls, would also be be better done in alternating fashion.

 

The exercise below - ***Decline Dumbbell Press*** - would be classified as a "Simultaneous Unilateral" exercise. Each arm is working independently, but at the same time as the other arm. Again, there is a clear advantage in using both arms simultaneously: better balance. As we saw in the previous chapter, using only one arm at a time (and using a heavy weight) would pull the user over to one side. Doing them simultaneously counter-balances this (provides stability) - yet each arm is working independently, so the cross-over (contralateral / neurological) benefit to each side is maximized.

 

In all three of the above exercises, I am doing a different version of a Unilateral Exercise. But, in all three cases, the arms are still working independently of each other. The only difference between the three, is the timing between repetitions. In the first exercise, I perform all the repetitions with one arm, and then do the same with the other arm. In the second exercise, the timing is “left / right / left / right”. In the third exercise, the timing is simultaneous.

Of course, there are many other exercises where each of these types of “unilateral” are best applied. But the logic used above can be applied to all exercises. The goal is to seek stability, proper form (alignment), the avoidance of strain to areas that are not the target, and maximum ability to focus on the task at hand - all while allowing the limbs to work independently, whenever it’s practical to do so.

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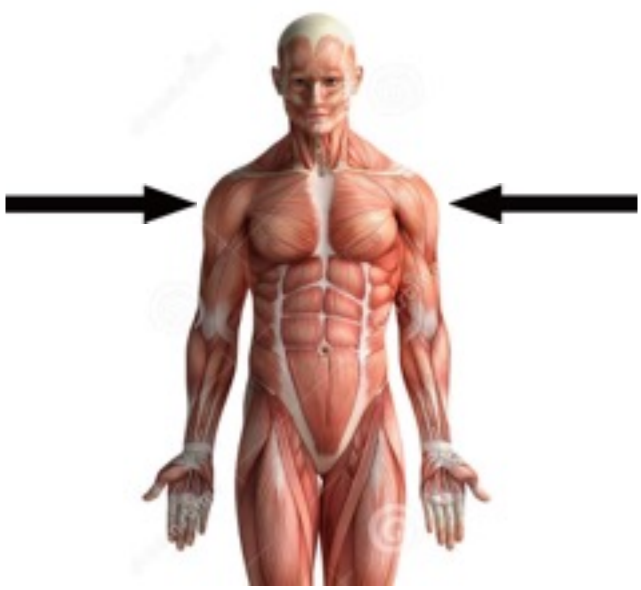
“Uni-Directional Focus”

In **most** cases, the direction of movement produced by a muscle on the left side of our body, is the same as the direction of movement produced by that muscle on the right side of our body. For example, the left and the right Biceps BOTH produce movement in the same direction - “upward”, if we’re standing. The left and the right Triceps BOTH produce movement that is “downward” - if we’re standing. This is also true of the Quadriceps and Hamstrings. This is because these muscles are on the same side of our body. The Biceps are both on the anterior side; the Triceps are both on the posterior side.

However, a few muscles produce movement in opposite directions, because they are positioned on the opposite sides of our body. For example, the right Lateral Deltoid faces toward the right, but the left Lateral Deltoid faces toward the left. Therefore, the right Lateral Deltoid produces movement toward the right, and the Left Lateral Deltoid produces movement that is toward the left. Those are OPPOSITE directions.



Although you may be unaware of it, moving in two different directions requires a type of "split focus" that ultimately compromises the exercise. This compromise does not occur when we do Triceps Cable Pushdowns, or Standing Dumbbell Curls - because we are able to use "Uni-Directional Focus" during those exercises. We either think "down" or we think "up"; we either lean forward or we lean back; we either brace against a downward resistance, or we brace against an upward resistance.

As you can see in the exercise shown above, the arms move **directly opposite** each other at the beginning of the movement - one to the left and the other to the right. We must focus in two different directions, at the same time.

As the two movements curve around their respective the shoulder axis, the path of both arms becomes less "opposite". But they never actually get to the point where both arms are moving in the same direction. The range of motion ends just before they reach that point.

This is one of the reasons why the *One Arm Lateral Deltoid Cable* exercise shown above is so good. It allows the user to focus all of his (or her) attention on a movement that is in one direction at a time. The exercise below - *One Arm Seated Side Dumbbell Raise* - allows the same "Uni-Directional focus".

I encourage you all to try this experiment, next time you’re at the gym.

Perform a *“Triceps Pushdown”* with your right arm, and a *“Standing Cable Curl”* with your left arm - simultaneously. Then perform a two-arm *Triceps Pushdown*, and a two-arm *Cable Curl*.

Compare how each **feels**, and how much weight you’re able use with each version.

What you'll discover is that it is more awkward to perform **two opposing movements** at the same time, as compared to doing either one direction of movement, or the other. In fact, the difference in apparent strength (power) could be as much as 20%. We are able to move more weight, and contract the target muscle better, if our efforts are either **entirely upward** or **entirely downward** - entirely to the **left** or entirely to the **right**.

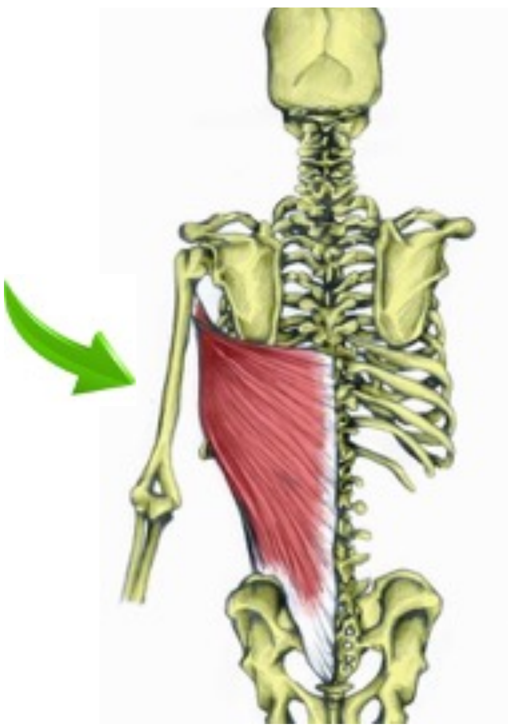
Since our objective is to achieve optimal muscular development, it makes sense to perform an exercise in a manner that allows the most control, the most contraction, and the most weight to be used. Of course, if one's objective is "optimal dexterity" or to challenge brain / body coordination, the recommendation would be different. But this book is intended for those pursuing optimal physique development, and the methods recommended here are with that in mind.

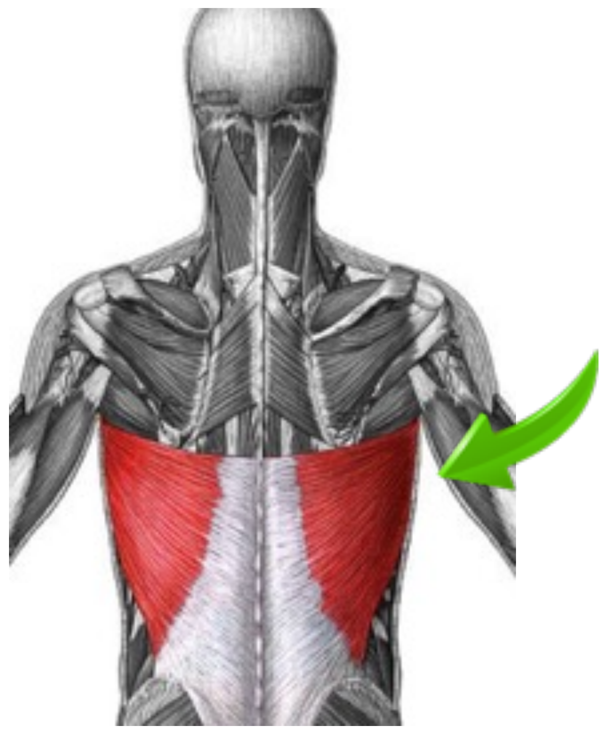
Which Other Muscles Produce Opposite Direction Movement?

The **Lateral Deltoids** are the primary muscles that produce movement in opposite directions.

The **Latissimus dorsi** could be considered the next most primary muscle, for which this "rule" applies. The Lats' origin is on the spine, so the ideal movement for the Lats would be inward - toward the spine. An inward movement would have to originate from the side, with a slightly upward angle - parallel with the direction of the Latissimus fibers.

In other words, the left Latissimus would ideally produce movement that originates from the left side and moves inward; the right Latissimus would ideally produce movement that originates from the right side and moves inward. These are opposite directions of movement.





Technically speaking, the Lats do not pull straight downward, nor do they not pull straight backward - so much as they pull inward, toward the spine. And the motion should ideally begin from a mostly lateral / slightly upward origin. They participate more in Pulldowns and Chin-Ups, than they do in Rowing motions, but neither movement is as ideal as a Pull-In (shown below). Performing this movement "one arm at a time" (Isolated Uni-Lateral) is significantly better than doing it with both arms simultaneously.

It would be difficult to pull from this **degree** of **SIDE** angle, with **both arms simultaneously**. You'll notice (in the photos above) that as the arm is pulled inward, there is a natural lean of the torso, toward the resistance - as well as a slight rotation of the torso, toward the resistance. Using both arms at the same time would prevent this natural torso lean and rotation from occurring.

It's also very easy to brace one's self with one's foot against a block, to prevent being pulled off the seat. There is no need to "counter-balance" one's self during this exercise, as compared with Supine Dumbbell Press. There is no way of securely bracing one's self during that exercise, therefore counter-balancing is required there.

The **Obliques** (Internal and External) are also on opposite sides of the body, and definitely fall into the category benefitting more from an "Isolated Uni-Lateral" exercise. But these muscles also fall into the category of "**Reciprocal Innervation**" because each side is the agonist / antagonist muscle of the opposite side. When the right side works, the left side SHUTS OFF, and vice versa.

Other, less significant (opposite side / opposite movement) muscles would include the sides of the neck, the Gluteus minimus and medius, and the middle Trapezius. But the sides of the neck are not "important" physique muscles; the left side / right side of the middle Traps can be easily worked simultaneously; and the Gluteus minimus and medius do not only perform lateral movement - they get enough work from Squatting / hip extension movements. Therefore, these four muscles do not require "Uni-Directional Focus", nor would they benefit from it so much.

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Summary

Cross-education is a physio-neurological characteristic that allows exercise performed by the limb of one side of the body, to benefit that same limb on the other side of the body - although to a much lesser degree.

This is useful for rehabilitation from an injury, as well as for "evening-up" muscular development differences on opposite sides of the body.

The studies demonstrating "cross-over benefit" from Ipsilateral limb (the one that is working) to the Contralateral limb (when not working), suggests there is a distinct advantage to Iso-lateral / independent limb exercise. Therefore, using dumbbells likely provide more muscular / neurological benefit than using a barbell.

Exercises performed with independent dumbbells or independent cables qualify as "Iso-lateral", even when both limbs are working simultaneously. The term "Bi-lateral" should not be used to define an exercise where two dumbbells are lifted simultaneously. The term "Bi-lateral" (in exercise) should be used to describe two-limbed exercise that shares a single instrument - like a barbell.

Lateral Deltoids and Latissimus dorsi are muscles that benefit more from Isolated Uni-lateral exercise more than from simultaneous Uni-lateral exercise or Bi-lateral exercise, because the left side and right side produce "opposite direction movement".

(1) School of Medical Sciences, Health and Exercise Science, University of New South Whales, Sydney, New South Whales, Australia

(2) Hortobagyi T, Lambert NJ, Hill JP. Greater cross education following training with muscle lengthening than shortening. Med Sci Sports Exerc 1997; 29:107-112.

(3) Zhou, Shi. Cross-Education and Neuromuscular Adaptations During Early Stage of Strength Training. Journal of Exercise Science and Fitness. 2003. 1(1), 54-60.

Lee, M., Carroll, T. Cross-Education: Possible Mechanisms for the Contralateral Effects of Unilateral Resistance Training. Sports Medicine. 2007. 37(1), 1-14.

(4) Milène Catoire, et. al., Pronounced Effects of Acute Endurance Exercise on Gene Expression in Resting and Exercising Human Skeletal Muscle, Plos One, 7:11 (2012)

(5) Howard JD, Enoka RM. Maximum bilateral contractions are modified by neurally mediated interlimb effects. J Appl Physiol 1991; 70:306-316.

*(6) "Several articles have reported **non-local**, as well as cross-over (contralateral muscle) effects with an exercised muscle affecting the performance of a non-exercised muscle when monitoring fatigue."*

Chapter Seventeen

Assessing & Selecting Exercises

for Physique Development

In the previous chapters, we discussed issues that mostly relate to the "direction of resistance", and how it affects a given exercise. The direction of resistance determines "alignment", "efficiency", "early phase loading", "opposite position loading", etc.

In the following chapters, we'll discuss issues that relate to the ideal "direction of movement" for a given muscle, based on the origin and insertion of that muscle, as well as the apparent joint design, over which that muscle crosses.

The combination of these two features (direction of movement and direction of resistance) allow us to identify the exercises that could be considered "BEST" for each muscle group. All exercises could be rated on a scale of 1 to 10 (worst to best), on this basis.

If one's goal is maximum training efficiency (most benefit, least wasted effort, least injury risk), the wisest approach is to use only the "best" exercises, and forego the exercises that rate poorly.

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In Chapter 2 ("*Active Levers & Neutral Levers*"), I explained how an exercise like a standard *Barbell Squat* could be considered "compromised" (as a Quadriceps exercise), due to the fact that the tibia is only about 35% "active", at best. I also explained how *Parallel Bar Dips* could be considered "compromised" (as a Triceps exercise), due the the fact that the forearm-lever is only about 11% active, at best.

In Chapter 8 ("*Opposite Position Loading*"), I explained how a standard *Seated Cable Rowing* exercise could be considered "compromised", due to the fact that the target muscle's origins (Latissimus and middle Trapezius) are **not** positioned directly opposite the direction of resistance. I also offered better-option exercises for each of the three compromised exercises above.

The "compromises" cited above - and in those previous chapters - are due to having the **direction of resistance** (in a given exercise) being less than ideal. These compromises translate to a loss of efficiency. In other words, the target muscle only receives a fraction of the possible benefit, while spending more energy than necessary.

Apart from issues that relate to an incorrect direction of resistance, an exercise can also "compromised" because the anatomical motion it requires is not ideal. An exercise could be classified as anatomically incorrect if its movement fails to mimic the target muscle's primary function - or, if it distorts and strains a joint.

It is important to identify exactly what each physique muscle does, as its **primary** function. Once that is established, we can see how departures from that specific motion gradually results in decreased effectiveness or unproductive contortion.

An "ideal" exercise combines the following:

1. **It mimics a target muscle's primary motion,** and has mostly full range of motion

2. It utilizes a **<u>direction of resistance</u>** that:

    2-a Is in **alignment** with the direction of motion, and also with the origin and insertion of the muscle

    2-b Provides a **productive resistance curve**, taking into account "early phase loading" and "mechanical disadvantage"

    2-c Pulls in a direction that is directly opposite the target muscle's origin, for "**opposite position loading**"

3. Utilizes mostly "**active**" levers (limbs)

4. Does not load non-target muscles more than the target muscle

5. Does not unnecessarily strain a joint

Exercises that fail to meet these standards, typically do so in gradations. Some exercises are less than ideal, but are still fairly good. Other exercises fail miserably on multiple levels. Others fall somewhere in between.

The point is that exercises all have a different value (i.e., level of productivity, energy cost and injury risk), of which we - in the profession - should be aware. We should know the principles by which an exercise qualifies as “excellent”, “in-efficient” or “dangerous”. We should know whether two exercises for the same muscle produce a different result, or are mostly redundant. We should be able to explain - in terms that are logical, factual and scientific - how each exercise works.

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There are several very logical ways of identifying a **muscle’s primary function**.

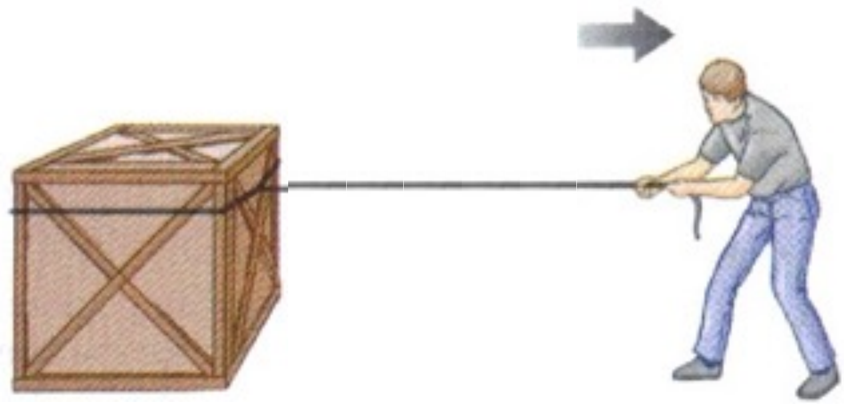
The origin and insertion points of a muscle provide us with the primary clue. When looking at an anatomical illustration of a muscle, we can clearly see where these two points are located. We can also see the joint(s) over which that muscle crosses. When that muscle contracts, it brings its origin and insertion points closer together - which causes the joint to move (flex, extend, rotate, etc.).

All muscles pull toward their origin

A muscle fiber is like a rope, which pulls its insertion point toward its origin. For example, the Pectoralis major participates in numerous functions, even when we’re just washing dishes in the kitchen sink. However, there are specific movements that can be designated as the Pectoral’s “best” or “ideal” motions. Likewise, there are various movements that can be designated as “varying degrees of NOT ideal”.

A muscle might be “**barely participating**” in a task, because the motion does not closely mimic that muscle’s ideal motion. Or it might be “**engaged a little more**” in a task, because that task is slightly closer to its primary function. Or it might be “**participating substantially**” in a movement, because that motion is even closer to its primary function. Or it could be “**fully engaged**” because the motion is precisely what that muscle is designed to do.

One of the ways I like to explain this concept is to imagine yourself holding the end of a rope, of which you have tied the other end to a heavy box. When you pull that rope, the only direction in which you can pull that heavy box is directly TOWARD you. You cannot pull that heavy box in any direction OTHER than toward you. Muscles operate the same way. Their **origins** are in a fixed location on the anatomy, and they pull whatever limb is connected to their insertion point, directly toward their origin.

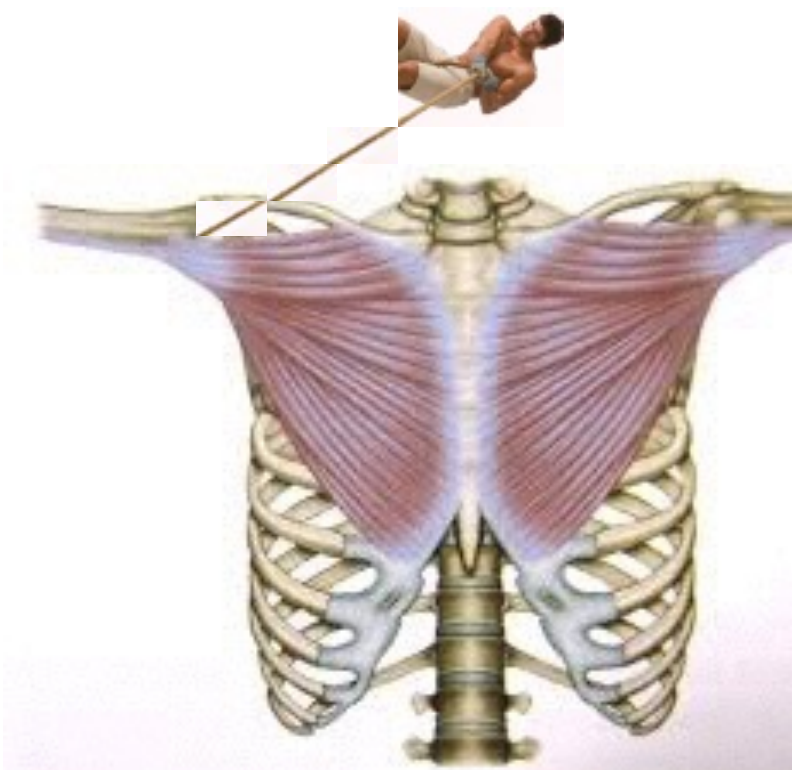


In the illustration below, we see this same concept, applied to the anatomy. The man below is "standing" on a human sternum, where most of the Pectoral muscle fibers originate. Imagine he is holding a Pectoral fiber - like a rope - pulling a loaded humerus. The only direction in which he can pull that humerus is toward him. Of course, a number of the other Pectoral fibers are likely also pulling, so the humerus moves in the direction of the combined efforts. But the combined efforts still move the humerus toward the Pectoral origins on the sternum.

Since each muscle fiber origin pulls directly toward itself - and only toward itself - the first step in knowing "which direction a muscle pulls" (or what motion a muscle ideally produces), is knowing where its origins are.

It's worth noting - in regards to the Pectorals - that once the arms are raised so that they are perpendicular with the torso, **ALL** the Pectoral fibers are either parallel with the humerus, or **below** the humerus.

There are NO Pectoral fibers above the arm line, nor above the clavicles. So, it is **impossible** for the Pectorals to participate much in pulling the arms in a direction that is above the clavicle line. Yet, one of the most common exercises performed in the gym is **an INCLINE press** - which moves the arms in a direction where there are NO Pectoral fibers. The illustration below shows from where the Pectorals would have to pull, in order to produce an "incline" movement.



In other words, **Incline Presses** do NOT work the upper Pecs very well - even though we've been told for years that "*The best exercise for the upper pecs is Incline presses*". This has been the conventional wisdom for decades. However, one would have to have Pectoral muscle origins on the front of their neck, or on their chin, in order to have Pectoral muscle fibers that pull the humerus in that direction.

This is one example of how understanding that "muscles always pull toward their origin" (and knowing where the Pectoral origin and insertion points are) allows us to realize that this decades-long belief is actually FALSE. It was ill-conceived by early bodybuilders - who were unaware of bio-mechanics. It has been passed on by sheer tradition.

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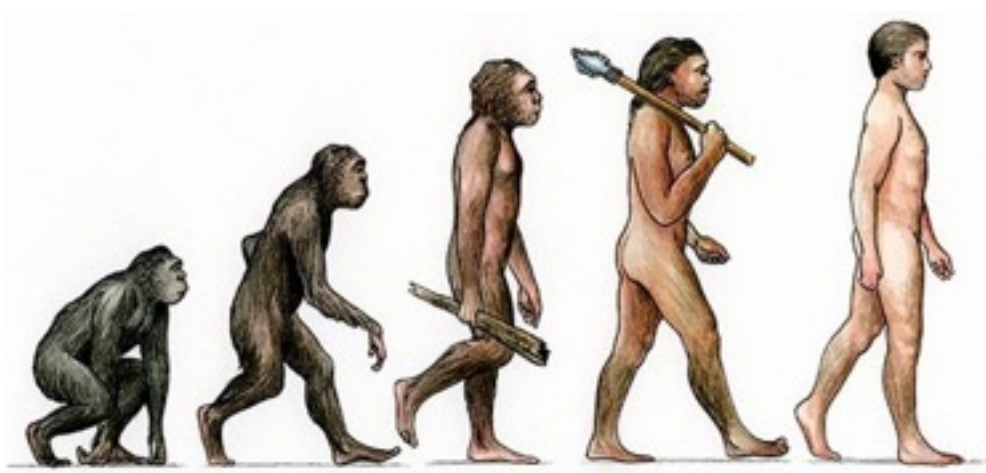
Evolutionary Need

Another way of getting a sense of what might be considered "ideal" anatomical motion, is to consider our evolution. The anatomy we have - our skeletal design and muscular connections - have evolved over millions of years, for the purpose of survival.

Although none of us were alive a million years ago, we can reasonably assume what our early ancestors probably did from day to day. It's reasonable to assume there were no "incline benches" during those days. Any "weights" that were lifted were logs and heavy rocks, and those could not possibly have been moved in a direction that was 45 degrees upward from the torso (i.e., an "incline" angle).

We evolved from quadrupeds, and gradually began walking more upright - using our Pectorals in increasingly downward ("decline") directions.



The fact that our Pectorals are entirely below our arm line, demonstrates that they were used to push in directions that were below the arm line - over millions of years.

Therefore, it's safe to assume that "incline angle pushing" with the humerus was not an evolutionary requirement for survival. The fact that the humerus is ABLE to do that movement, does not "prove" that our Pectoral muscles perform that task, nor that they'll benefit from that task. We are also **able** to put our forearm behind our backs, yet there was likely no evolutionary **need** to that either.

In addition to there being a correlation between the way our muscles perform today, and the evolutionary needs of our early ancestors - there is also a correlation between the way our joints operate today, and our evolution.

For example, it's **not** likely that our early ancestors needed to hold a heavy log or rock, directly over their heads, and then push it straight up and down repeatedly. What could possibly be the purpose of that? Of course, this would be like an Overhead Press.

Certainly, they may have needed to push or throw a heavy log or rock, in a **forward** direction. But movement in an overhead direction, or an "incline" direction, seems extremely unlikely.

As we examine the shoulder joint, we can also see that "impingement" of the Supraspinatus tendon (and of the bursa) is inevitable, when moving our arms directly overhead. This should not surprise us - knowing that our earliest ancestors probably NEVER had to move their arms (while heavily loaded), up and down, directly overhead, repeatedly. Clearly, our shoulder joint was not designed to perform this task. There could not possibly have been an evolutionary need for it, and the anatomical structure of the shoulder seems to corroborate that.

So, in the following chapters, we may - from time to time - pause and consider the original "intention" (purpose) of a particular muscle, and compare that to whatever the current method of exercise is for that particular muscle. You'll see that doing this will help shed light on whether that current exercise method is "ideal" - and whether there is a method that more closely resembles its intended purpose.

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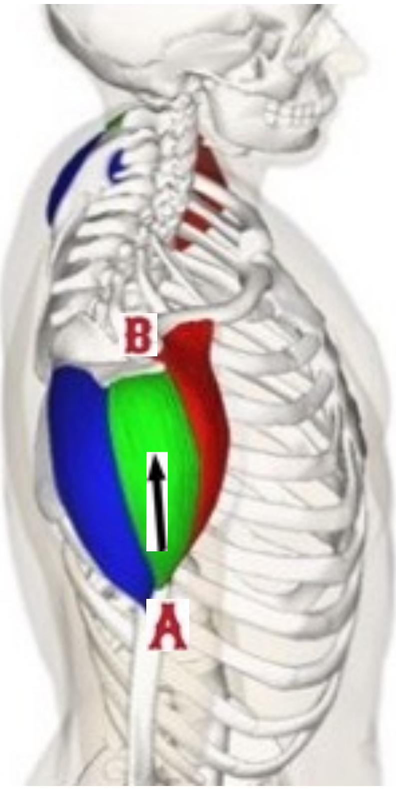
Movements that are most "natural" are best

Rather than assuming muscular development requires a complex movement (elaborate exercise), it's more logical to assume that a simple movement would be required.

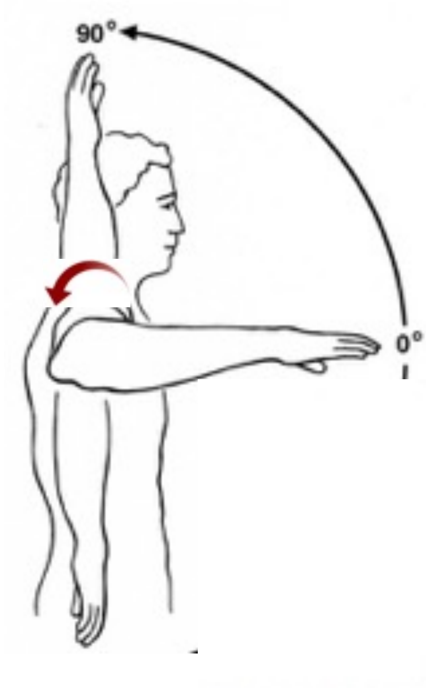
For example, let's look at the Lateral Deltoid (shown in green below). Think of the simplicity of the insertion point ("A" on the humerus) moving directly toward the origin point ("B" on the edge of the scapula), as the muscle contracts. That would raise the arm to the side - a movement called "Lateral Abduction" - a *Side Raise*, of some kind. It is the purest, most natural function of the Lateral Deltoid.



Performing this muscle's most natural function - a *Side Raise* - with the **<u>ideal direction of resistance</u>**, and enough load, is all that is required to stimulate muscular development.

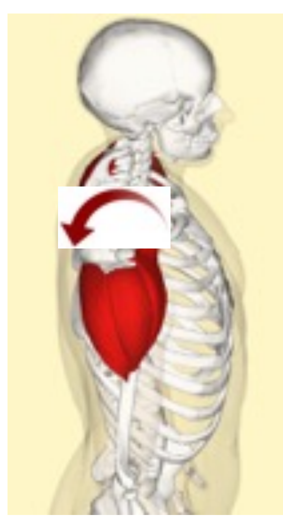
However, despite it being obvious that "Lateral Abduction" is this muscle's most natural movement, and despite it being very clear that moving the arms overhead causes shoulder "impingement", many people still believe that the ***Overhead Press*** is either a "good" shoulder exercise, or "the best" shoulder exercise.

However, *Overhead Press* is nothing like a Lateral Abduction. It requires a considerable degree of shoulder joint **contortion**. In the illustration below-left, we see a man rotating his humerus externally a full 90 degrees from its "normal" position, simply to be in position to do an Overhead press. This degree of external rotation is impossible for most people.



If one is unable to rotate their humerus enough to cause their forearm to be perfectly vertical, the forearm will have a forward tilt to it. We discussed this in a previous chapter. This forward tilt will unintentionally load (likely OVER-load) the Infraspinatus - one of the Rotator Cuff muscles. This happens to most people who perform Overhead Presses, because they are not able to position their forearm vertically (neutral position).

But even those who are perfectly able to externally rotate their humerus enough, the rotation of the humerus itself **compromises the potential benefit**. In the illustration below, we see a rotation arrow over the deltoid. This illustrates how the humerus must be rotated inside the Glenoid socket, in order to assume the Overhead Press position.



The attachment of the Lateral Deltoid is on the Deltoid tuberosity, on the **outer** portion of the humerus. When the humerus is rotated, the Deltoid tuberosity rotates with it - thereby shifting the attachment of the Lateral Deltoid toward the rear. When this happens, it diminishes the "opposing gravity" position of the Lateral Deltoid. Essentially, it moves it over to an 10:00 position - relative to the 6:00 direction of gravity. Therefore, its percentage of load will be significantly reduced.

As the Lateral Deltoid shifts toward the rear (by about 50%), the Anterior Deltoid shifts upward, more into the position opposite resistance. The result of this humeral rotation is more Anterior Deltoid load, and less Lateral Deltoid load - **plus** the strain of twisting the humerus inside the socket, **plus** the potential impingement issue. There are far more productive (and more safe) exercises for the Lateral Deltoid and the Anterior Deltoid than an Overhead Press.

Yes - a person **can** lift a heavier weight while *Overhead Pressing*, as compared with performing *Side Raises*. But this does NOT mean the Lateral Deltoid is working any harder, nor getting any more load. This exercise allows a heavier weight to be lifted because the arm length (lever) is reduced from "straight arm" to "bent arm" - which reduces the magnification of the weight. In addition, **three** muscles are participating in the moving of the weight, instead of one muscle.

In contrast, when doing *Side Raises*, the weight is magnified considerably more. This is due to using the **entire** length of the straight arm (the forearm plus upper arm). Plus, the Lateral Deltoid is not being helped by other muscles.

The length of the entire arm is approximately 25 inches, which would cause a weight magnification of about 20-fold. So, a ***Dumbbell Side Raise*** performed with a 20 pound weight, would actually load the Lateral Deltoid with approximately 400 pounds* (at the perpendicular position). This amount is likely to be as much - or more - as it would be during an Overhead Press. And, there would be no joint strain with the *Side Raise*.

(Note: The 400 pounds mentioned above does not include the additional force requirement caused by the Deltoid pulling on the humerus from a mechanical disadvantage / mostly parallel angle. The actual amount of force required by the Lateral Deltoid, when performing a Side Raise with a 20 pound dumbbell, would actually be far more than 400 pounds).

The point is that contorting the joint is NOT necessary for loading the target muscle. It does not improve the mechanics beyond the "normal" position. It actually compromises the mechanics of the Lateral Deltoid (makes it **less** efficient), and creates a risk of injury.

As you'll see in the following chapters, it is always better to perform exercises that are as close to our natural movement as possible. Conversely, the farther away we get from our normal anatomical movement, the more potential problems that are created - all **without** any additional benefit to the target muscle.

People tend to believe that muscular development requires fancy, complicated exercises. We see all kinds of strange aberrations of exercises in the gym, and NONE of them result in any kind of advantage, beyond that which is produced by the simplest movements. Many times, they produce less benefit and more risk of injury, than the simple movements.

By "simple movements", I am not referring to "Old School" exercises, nor to "Basic Power Exercises". I am referring to movements that are even more basic and simple than that, as you'll soon see.

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Joint Design

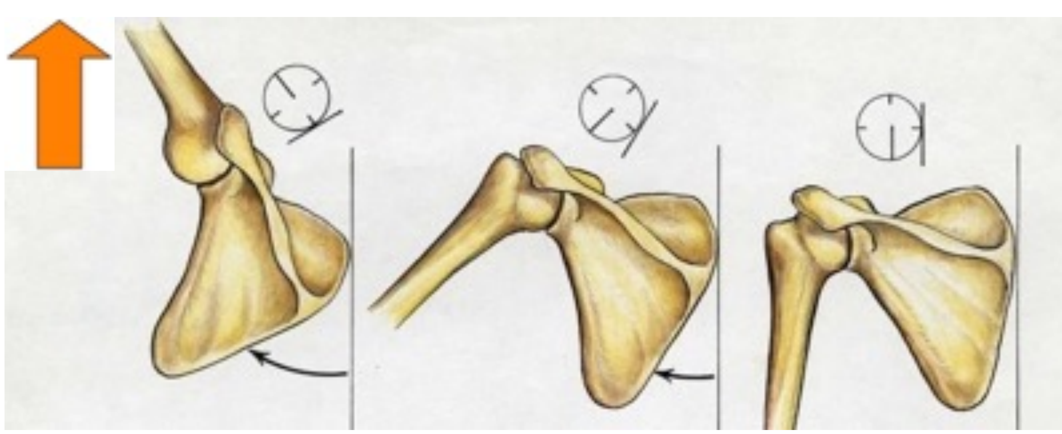
Another anatomical feature that informs us of a "muscle's IDEAL motion", is the design of the joint over which that muscle crosses. By understanding that joint's function, we are able to surmise the ideal motion, as well as the type of muscle activation. We can also surmise what is NOT the ideal motion, by understanding the consequence to the joint when it moves it that direction.

For example, the elbow joint only moves in one direction - it "opens" and "closes", like a hinge. The Biceps crosses the elbow joint. Therefore, **both heads** of the Biceps must participate simultaneously, and equally, any time it produces "elbow flexion", with resistance. Only if the elbow were able to bend in **multiple** directions, could the "inner head" or the "outer head" of the Biceps be preferentially activated.

As another example, the fact that **impingement** of the shoulder joint (Infraspinatus tendon and bursa) occurs when we repeatedly move our arms overhead (i.e., Overhead Presses), demonstrates that that is NOT an ideal motion for the shoulder joint, nor for the muscles that move the joint in that manner.

Impingement occurs when the upward-moving humerus squeezes the Infrapinatus tendon and bursa against the Acromion process (the upper-out edge of the scapula). While this is inevitable when doing an Overhead Press (below-left), it's much less likely to occur when doing Chin-Ups or Pulldowns (below-right).

The reason for this is that the downward resistance used for Overhead Presses, holds the scapula down, while the humerus moves upward underneath it. But, when we do Chin-Ups or Pulldowns, the upward pull of resistance pulls the scapula upward as well, allowing more space between the humerus and the Acromion process (illustration below). This does not completely eliminate the risk, but it reduces it considerably.



Of course, this is not surprising in light of our evolution. It's easy to imaging our early ancestors climbing, pulling downward on tree branches - even if the **angle** of pull was slightly different than a Pulldown or Chin-Up.

Skeletal limitations inform us what we **cannot** - or "should not" - do, in terms of exercises. However, this combined with knowing the origin and insertion of the target muscle, allow us to have a more complete sense of what we **should** do - of what would constitute an "ideal" anatomical motion, and therefore an "ideal" exercise.

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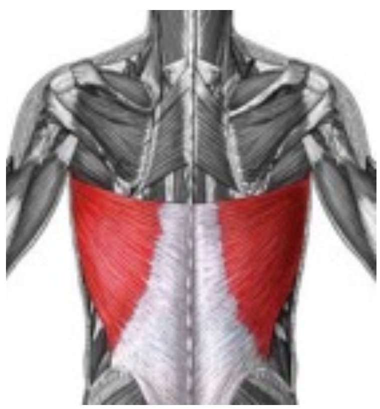
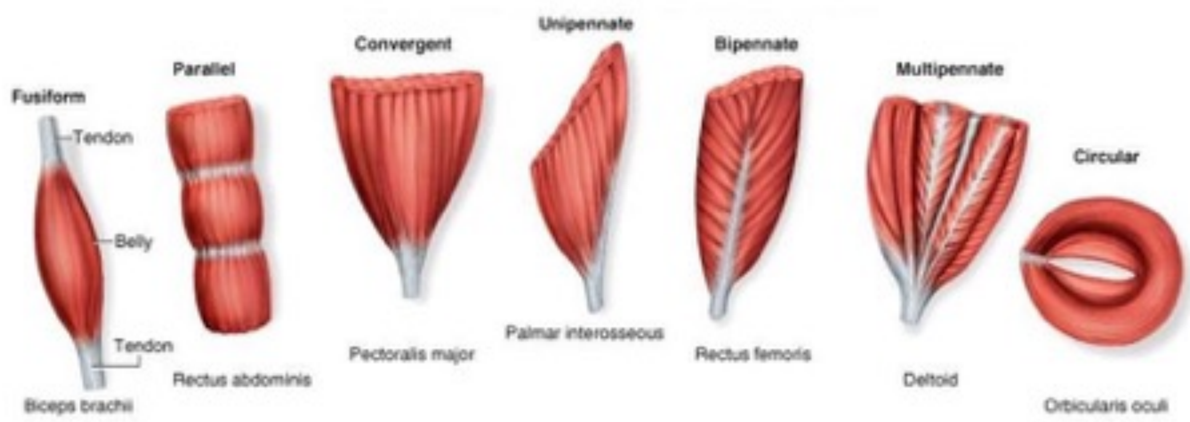
The Direction of a Muscle's Fibers

In some cases, it's easy to see in which direction a muscle pulls its operating lever, by identifying the direction in which its fibers are situated. For example, the Pectoral fibers almost "point" in the direction they pull - on the sternum, clavicles and ribs. This is also true, to a degree, with the Latissimus dorsi and the Biceps. However, not all muscle fibers are "straight", like those of the Pecs, Lats and Biceps.



In fact, there are seven types of "muscle architecture". Three of these have fibers that run in straight lines, and three have fibers that run diagonal to the origin and insert of the muscle. These are called "Pennate" fibers. The illustration below shows the seven type of muscle architecture.



"Fusiform", "Parallel" and "Convergent" - all have fibers that run in the same direction as the line that can be drawn between the muscle origin and insertion. The primary difference between these three is the way they converge with their tendon.

"Unipennate", "Bipennate", and "Multipennate" - all have fibers that cross diagonally to the line that can be drawn between the muscle origin and insertion. The seventh type is called "Circular", and is only found at the opening of the eyes, mouth and anus.

Pennate muscle has a stronger ability to contract, as compared with straight muscle fibers. This is because these fibers pull on their tendon from an angle, so they don't move their tendon **as far** as straight muscle fibers would. This is similar to the physics of a bicycle that has a "low gear" for hills, and a "high gear" for flats. Pennate muscles are essentially "low gear" muscles. It trades distance for power (torque).

Pennate muscle also packs **more muscle fibers** into a given space, because they're angled. This also produces more strength capacity, as compared with a parallel muscle of the same size. The more muscle fibers, the more myofibrils and sarcomeres, which translates to greater power.

You have probably noticed that Triceps and Quadriceps have "cross hatching" striations - while Biceps, Pecs, Lats and Hamstrings have straight muscle striations. Triceps and Quadriceps are "extension" muscles, and have Pennate muscle fibers.

In Chapter Three, I explained that muscles which "flex" a joint (Pectorals, Biceps, Hamstrings) are more vulnerable to tearing / rupture, as compared with muscles that "extend" a joint.

However, muscles that **extend** a joint have apparently adapted to the fact that they ALWAYS operate with a Mechanical Disadvantage - they always require more force. So, they evolved as Pennate muscle to accommodate that need. Conversely, muscles that flex a joint have the "advantage" of sometimes being able to operate with a

Mechanical Advantage - which allows them to produce anatomical movement with less muscle force. However, this also makes them more vulnerable to injury when they enter Mechanical Disadvantage, at certain angles.

In any case, we cannot always use “muscle fiber direction” as an indicator of proper muscle function - but it is convenient sometimes. However, when we are evaluating the function of a Pennate muscle, the line that can be drawn between the muscle’s origins and insertion serves equally well.

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Bad, Good, Better and Best

Once the ideal anatomical motion has been identified, for a particular muscle, we can then identify the ideal direction of resistance for that motion. The ideal direction of resistance would provide the advantages listed above - proper alignment, optimal resistance curve (early phase loading / relief from mechanical disadvantage if necessary), opposite position loading, and the use of mostly active operating levers.

As you can imagine, this combination of exercise characteristics greatly limits the number of exercises that would be classified as “ideal”. It also allows us to have a sense of which exercises are farthest from “ideal”, and which ones would fall somewhere in between.

A person could - theoretically - quantify the physics of each exercise, and issue each exercise a “placing” or a rating. This could be done either on the basis of, “1st best, 2nd best, 3rd best”, etc., - or the exercise could be given a rating between 1 and 10, with 10 being best. This would be a “judgement call”, of course - although an informed one.

For example, you now know that *Parallel Bar Dips* load the Triceps with approximately HALF as much load as a *Supine Dumbbell Triceps Extension* ("DB Skull Crushers"), even though four times more resistance is used. This would absolutely qualify *Supine Dumbbell Triceps Extensions* as **"better than"** *Parallel Bar Dips* - as a Triceps exercise. We could call *Supine Dumbbell Triceps Extensions* a "10", and we could call *Parallel Bar Dips* a "5".

(Note: While we're at it, I would consider Dumbbell Triceps Kickbacks a "3", as a Triceps exercise.)

So, the question is, "If a person is truly dedicated to physique development, and wants maximum efficiency (the most benefit, the least wasted effort, the least injury risk), why bother using exercises that rate lower than a 9 or a 10 ?".

I am not suggesting that an exercise that rates a "5" should never be used. I am merely suggesting that a person **be aware** that they are using a less efficient exercise, when they're doing it. It should be a conscious, informed decision. People should not assume all exercises have equal productivity, equal "cost" and equal risk. If they WANT to "mix it up" for the sake of fun, variety or convenience - it's fine, provided they understand the trade-off.

Of course, doing only the exercises that are rated highest, will make workouts seem more repetitive. This may make some people nervous, because they've heard for so long that they need to continuously change exercises. But it's simply not true. They've bought into the marketing hype. People **mistakenly** believe that different exercises "shape" muscles differently, and that different exercises provide the "necessary variety" to prevent "stagnation". But these beliefs are both entirely false, as we'll soon see.

Also, some of the most dramatic exercises to watch are NOT the most productive for muscular development. And, the exercises that are most productive, are usually not very "sexy". They're much less "dramatic" to watch, or to photograph or to video-record. But these (mechanically superior) exercises absolutely WORK better, despite being less visually interesting or impressive.

Most people immediately FEEL the advantage of using the better exercises, in terms of the quality of their muscle contraction, muscle soreness, and muscle gain. Others, however, will likely be afraid to use only the highly rated exercises, and will combine them with other, less productive exercises. Unfortunately, those people will not truly KNOW which exercises contributed more or less to their results, and will continue wasting time and energy doing the less productive exercises.

Other people will claim with absolute certainty that, "It is essential for us to change exercises - every four to six seeks - so that our muscles don't adapt to any one exercise." Despite their confidence in making this statement, this theory has never been proven. Be assured, the person making the statement has never personally tested the theory he (or she) is so confidently espousing. And the people from whom he (or she) has heard this theory, ALSO have never actually tested it. Everyone just embraces it without requiring proof, and without reservation.

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Is It Really Necessary to Change Exercises Regularly ?

While there are some advantages to changing exercises occasionally, **physiological benefit** is NOT one of them. Yes, it's more **fun** to change exercises, and sometimes the station or equipment we want to use is not available - so it may be more **convenient**. But the claim that a muscle <u>benefits</u> from a changing exercises, is false.

Let's start with the simplest question: What does a muscle "sense" from an exercise?

Imagine that you are Pectoral muscle, for a moment. Imagine that your left hand is holding onto the ORIGIN point (on a person's sternum), and your right hand is holding onto the INSERTION point (on a person's humerus). You have no eyes, so you cannot SEE anything this person is doing. All you can do is FEEL.

Here are the things you (as the muscle) <u>**cannot**</u> possibly "know" (sense):

1. You don't know what the resistance **source** is (free weight, cable, machine, etc.).

2. You don't know the position of the person (standing, sitting, lying supine, facing north, facing south, etc.)

3. You don't know whether you (the muscle) are working alone (i.e., "isolated"), or with the help of other muscles ("compound").

4. You don't know whether the resistance you feel is comprised of a heavy weight with less magnification (*i.e., a short lever, mechanical <u>ad</u>vantage and a mostly neutral lever*), or if it is comprised of a lighter weight with greater magnification (*i.e., a longer lever, mechanical <u>dis</u>advantage and a mostly active lever*). All you know is "how much" resistance you're feeling.

Here are the things you (as the muscle) <u>**DO**</u> "know" (sense):

1. You know whether you're performing a full range of motion, a partial range of motion, or a static contraction (no range of motion).

2. You know whether the resistance is greater at the beginning of the range of motion, and lighter at the end. Or vice versa. (i.e., the "Resistance Curve", "Early Phase Loading" versus Late Phase Loading)

3. You know whether the load you're lifting is "heavy", thereby limiting you to six repetitions…or whether it's "light", thereby allowing you to perform 20 or 30 repetitions.

4. You know whether you're working at near maximum capacity, or not….whether you're feeling a high degree of fatigue, or not.

Each of these are "**bio-mechanical components**". As such, each of these characteristics have a "**better than**" or "**worse than**" value. Any change of exercise that effects the bio-mechanical components will be perceived by the muscle as either "better than" or "not as good as", the bio-mechanical components of another exercise. They won't only be perceived as "different".

For example, it is better to use full range of motion, rather than partial range of motion. It is better to use Early Phase Loading, rather than Late Phase Loading. It is better for a muscle to contract dynamically, rather than isometrically.

It is never advantageous to change from "good bio-mechanical components" to "inferior bio-mechanical components". And any change that does not alter the bio-mechanical components of an exercise, will not be perceived by the muscle as a change at all.

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Does the Body Really Adapt to the "Same" Exercises?

This belief is without logic or common sense - let alone scientific evidence. Let's look at a couple of comparative situations, and see if it makes sense.

Exposure to UV light produces stimulation of pigment, which results in a TAN. Certainly, a person adapts to sunlight, such that they reach a sort of limit - in terms of skin darkness. When that happens, should a person switch to a different type of light? Incandescent? Fluorescent? Infrared? No, because UV light is BEST for the stimulation of pigment.

Of course, a person can only get so tan. Likewise, a person can only get so muscular. But, skipping a few days of sun exposure, makes UV light "new" again, and a person will be susceptible to burning. Likewise, skipping a few days of exercise, makes exercise "new" again - and a person will get sore all over again.

(Note: Soreness is not necessarily an accurate indicator of having had a productive workout. A muscle can grow without (or with less) muscle soreness, and it may grow less (or not at all) with muscle soreness. They do not go hand-in-hand. Typically, those of us who train year-round continue to make progress, even though post-workout soreness is minimal.)

Another example is the food we consume. If we were to eat the 50 most nutrition food all the time, would we ever become "accustomed" to those foods, such that we are unable to extract the nutrients from them? Of course not. Should we consider changing to less nutritious food occasionally? Would that benefit us? Of course not.

Likewise, it is foolish to change from a highly efficient exercise (like *Supine Dumbbell Triceps Extensions*) to a less efficient exercise (like *Triceps Kickbacks*), and expect to load the muscle more, or expect better development. The muscle will simply perceive the change as "inferior", and will benefit less from it.

For a number of years, I went along with the belief that I needed to use a variety of exercises, and that we should change our exercises frequently. But eventually I realized that this did not make sense. Once I understood what constitutes "superior bio-mechanics" of an exercise, and I identified the best one or two exercises for each muscle, I began using only that one (or two) exercises for each muscle, every time I worked those muscles.

The result has been better development and less wasted energy. It has not changed the shape of my muscles, and I have avoided the joint strain that commonly occurs with many traditional exercises. I am currently preparing for the 2014 World Championship (bodybuilding), and continue using the same exercises for each muscle that I have been using for the past two years - without variation. My progress is as good as ever, and I expect to make a great showing at the end of this year.

We can vary the intensity of an exercise (more weight / more repetitions), and we can increase the overall volume of work (more total sets) - both of which **do** benefit the muscle. But there is **no** real benefit to doing multiple exercises, per body part*, per workout, nor in changing exercises every four to six weeks.

*(Note: The only possible exception is the Pectorals, which could benefit from **two** exercises / two angles. All other muscles only need one exercise per workout.)*

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Testing the Theory

The reason I can say with confidence that "no one has ever tested the theory" is because few people are willing to do only one exercise, for each physique muscle, for an extended period of time (six months or more) - as an experiment. Even fewer would know how to conduct the test properly.

The be clear, the test would NOT be comparing the results of doing one **random** exercise for a six month period of time, against the results of doing four different exercises in rotation for a six month period of time.

The test would be to compare the results of doing a single exercise that **rates a <u>10</u>** (in terms of efficiency), against the results of doing four RANDOM different exercises in rotation.

For example, if a "random" Triceps exercise is selected for the first six month - and it rates a "5" - and the four Triceps exercises selected for the next six months rate a 4, 6, 7 and 8 - the results will be better for the second six months. However, it will <u>not</u> be because of the exercise rotation. It will be because the four exercises used for the second part of the study average a 6.25.

Conversely, if the test uses a Triceps exercise that rates a **<u>10</u>** for the first six months, and then uses those same **other** Triceps exercises for the second six months, the result will be very different. The single ("10") Triceps exercise that is used for the first half of the experiment, will produce a better result than the four (average 6.25) Triceps exercises used for the second half of the experiment - guaranteed. It's inevitable.

Efficient exercises (that rate a "10") load the muscle most, waste the least amount of energy, do not strain the joints, and create the least risk of injury - even when used exclusively. It is **NEVER** more productive to switch from an exercise that rates a 10, to one that rates a 5 or a 6.

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Summary

Assessing an exercise from the perspective of bio-mechanical efficiency (maximum load on the target muscle, minimum wasted / unproductive effort, minimal injury risk) requires knowledge of two categories:

1. "Ideal" direction of resistance, in order to provide:
    a. Alignment
    b. Opposite Position Loading
    c. Early Phase Loading / productive resistance curve
    d. Relief from Mechanical Disadvantage, where necessary
    e. Mostly "active" levers working for target muscle / mostly "neutral" levers working for non-target muscles

2. "Ideal" anatomical motion for each physique muscle, based on:
    a. Target muscle insertions moving directly toward target muscle origins
    b. Movements occurring in ways that are most "natural" to muscles and joints
    c. Sufficient Range of Motion / Dynamic Muscle Contraction

An exercise that complies with all of the above prerequisites, is more productive, more efficient, and more safe. The degree to which an exercise fails to comply with the above prerequisites is commensurate with its degree of inefficiency, unproductiveness, and/or tendency to cause injury or strain.

We can thus determine which exercises are “best” for each physique muscle, which ones are compromised, and to what degree they are compromised. This allows us to establish which exercises are “bad”, “good”, “better” and “best”.

A compound exercise can also be evaluated this way. It could be deemed as “good”, if it combines motions that are each, individually, optimally productive and safe. Conversely, a compound exercise that combines two or more motions, of which one or more motions are contorted, out of alignment, not 100% natural, or has compromised resistance curve, must be valued **less**, for that reason.

A muscle typically produces one “ideal” motion (for purposes of physique development). This is determined by examining the anatomical motion that is created when the muscle insertion moves directly toward the muscle origin, in the simplest (least contorted) manner. Therefore, it is not necessary to use more than one exercise, per muscle, per workout. There are **not** “multiple ways” a muscle “needs” to be worked. The entire muscle is stimulated, when it contracts, while loaded. The exception to this is the Pectorals - and, to a lesser degree, the Trapezius.

A muscle cannot change its genetically-determined shape, regardless of which exercises are used.

A muscle does not get “accustomed” to an exercise, such that it no longer benefits from that exercise. If an exercise has excellent bio-mechanical characteristics (“ideal” direction of motion, productive resistance curve, proper alignment, etc.), a muscle will always benefit from that exercise - even if that exercise is used exclusively. Switching from an excellent exercise, to an exercise that has inferior bio-mechanical characteristics, will absolutely NOT benefit the muscle.

A muscle “super-compensates” (adapts upward) to accommodate the stress it experienced from a recent exercise. Super-compensation results in increased strength, fiber thickness, “sarcoplasmic” fuel reserve, etc. This process only takes three to six days. After that, the muscle begins its “de-conditioning” (if not exercised again) - thereby returning to its starting point after approximately 14 days. This is why we need to work a muscle **again** every three to six days - so that the hypertrophy continues.

For this reason, there’s no need to “shock” the muscle with a new exercise. A muscle is “shocked” every time it is exposed to the stress of an exercise - whether that exercise is “new” or not. The muscle is constantly adapting up or de-conditioning down, from its last exercise-induced stress.

What benefits a muscle most (from a hypertrophy / development prospective), is that the **bio-mechanical components** of an exercise be optimal. These include the following:

1. An exercise which moves the target muscle's operating lever **toward** the origin of that muscle (during concentric contraction), is BETTER than one that does not.

2. An exercise that provides full (or relatively full) range of motion, is BETTER than one that only provides static muscle tension for that muscle, or insufficient range of motion.

3. An exercise that provides alignment of the 1) direction of movement, 2) direction of resistance, and 3) the origin / insertion of the target muscle - is BETTER than one that does not provide that alignment.

4. An exercise that allows simple muscle contraction without contortion (twisting / straining) of a joint, is BETTER than an exercise that over-complicates the movement and contorts (twists / strains) the joint.

5. An exercise that provides a direction of resistance that is directly opposite the target muscle ("Opposite Position Loading"), is BETTER than one that does not provide that.

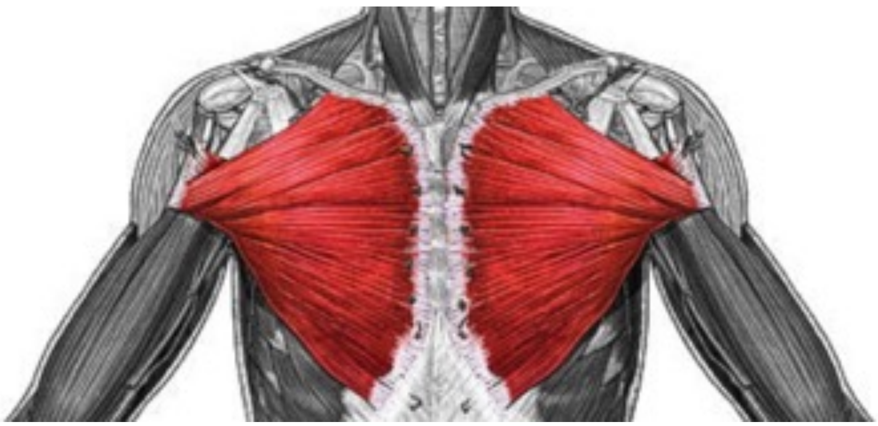
6. An exercise that provides "Early Phase Loading" is usually BETTER than an exercise that does not provide that. The exception would be exercises that coincide with a "flexion-oriented" Mechanical Disadvantage.

7. An exercise that involves a fully or mostly "active" (perpendicular) lever (limb), is BETTER (more efficient) than an exercise that utilizes a partially active lever, or a mostly neutral lever.

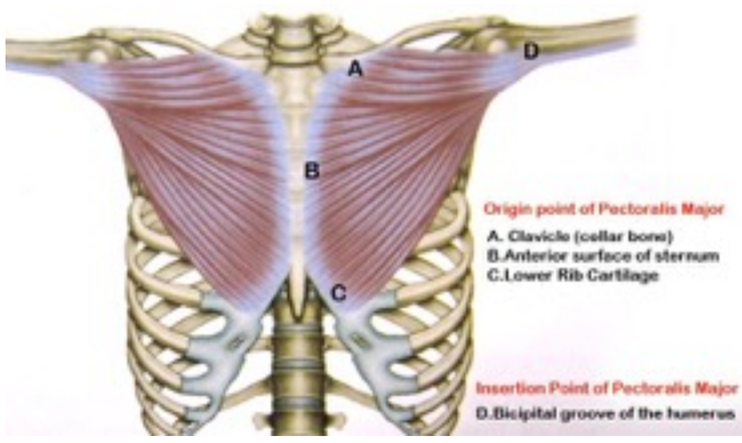
8. An exercise that employs a longer lever (not diminished by the "doubling back of a secondary lever", like a forearm or lower leg), is usually BETTER than an exercise that provides a shorter lever length / less resistance magnification.

Chapter Eighteen

Pectorals



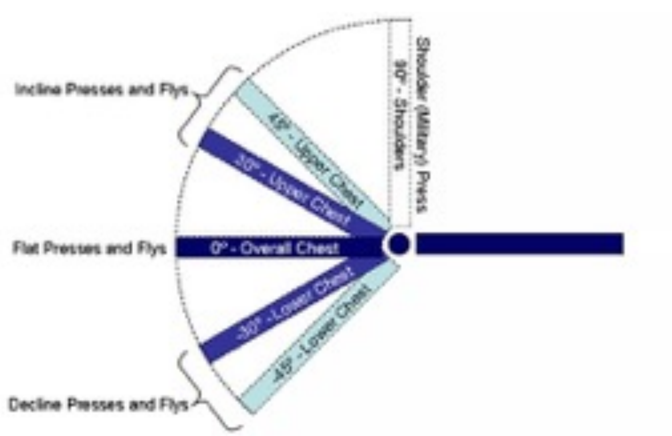
The “**Pectoralis major**” is a fan-shaped muscle that covers the top third of the front of the torso. Technically, it is comprised of three parts - called the “**clavicular**” fibers (“A” below), the “**sternal**” fibers (“B”), and the “**costal**” fibers (“C”). These names identify the origin of that particular group of fibers. The largest percentage of Pectoral fibers originate on the Sternum, while a smaller percentage originates on the Clavicles (highest), and on the “Costals” / ribs. The insertion of ALL the pectoral fibers is on the upper part of the humerus.



As noted in the previous chapter, when the arms are outstretched, ALL of the Pectoral fibers are situated **below** the arm line. This is obvious, when one puts their arms out to the sides like the man in the photo below. It's also clear in the illustration above.

The conventional wisdom, regarding the best exercises for the Pectorals, has been to use an **Incline** angle for the "**upper** pecs", a Flat bench for the center of the pecs, and a **Decline** angle for the **lower** pecs. But, this is not at all correct - as noted in the previous chapter.

That belief would theoretically make sense, if the arms were attached to the torso, so that half of the Pectorals fibers were above the arm line, and half were below the arm line - but that is not reality. The graphic below-**<u>left</u>** is one that has been circulated, suggesting which part of the Pectoral muscle the various angles (incline / flat / decline) would benefit. But when placed alongside a human figure (below-**right**), we can see that this belief is obviously incorrect.



Bench Angles for Barbell Presses and Dumbbell Presses and Flys

Moving the upper arm bone (humerus) TOWARD Pectoral origins is required, in order to stimulate those fibers. There would have to be some Pectoral fibers **above** the arm line, for an Incline angle movement to make sense. Since there are NO Pectoral fibers above the arm line, the **Incline angle is essentially worthless** - for the Pectorals. Only the flat and decline angles are productive.

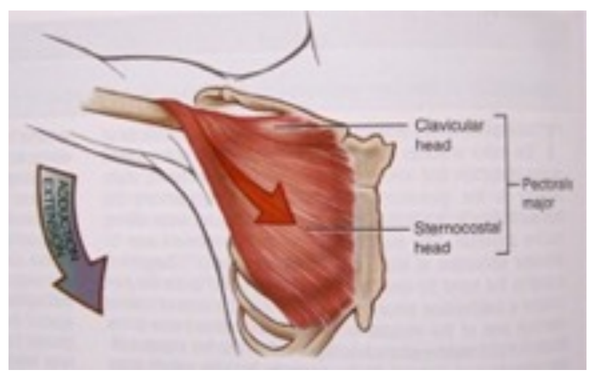
In the photo above, the blue arrow is pointing to this lady's clearly visible Clavicular Pectoral fibers. These are the Pectoral fibers that are highest on our chest. Yet, as you can plainly see in this photo, a ***Flat (Supine) angle Press*** engages them perfectly well. That is because (as you can see in the anatomy illustration above), those fibers are parallel with the humerus, and also parallel with the direction of movement, when performing any kind of flat bench press - as in a Supine Dumbbell Press.

Also, remember our analogy of the "Leaning Tower of Pisa", in Chapter 9. In the photo above, we could substitute her left arm for the "Tower', and YOU would be standing on her left Clavicle (on the opposite side of the Tower's lean), pulling the rope (the Clavicular Pectoral fibers), and thereby preventing the Tower from falling - or pulling it upward.

But a Flat (Supine) Press should **not** be considered the "best" angle, nor even the most "basic" angle, because it would not be moving the humerus toward the greatest number of Pectoral fibers. It would only be moving the humerus toward the top 20% of the Pectoral fibers.

In the photo below, a man is doing a ***Flat*** *Dumbbell Press.* We can clearly see, from this angle, that his upper arms have moved toward the highest part of his sternum. We can also see that there are no Pectoral fibers **visible** "higher" (to the left of his arm), yet there is quite a bit more Pectoral muscle visible to the right of his arm.

In the photo below-left, we now see the man performing a *Decline Dumbbell Press*. Notice how his arms are moving toward the **center** of his Pectoral origins - the area that is directly between the highest part of his Pectorals and the lowest part of his Pectorals.



When we perform a Decline Dumbbell Press - at this particular angle of Decline (approximately 20 degrees) - we activate the largest number of Pectoral fibers, because we are moving toward the area where there are the greatest number of Pectoral origins.

All three "parts" of his Pectorals - the Clavicular, Sternal and Costal fibers - contract when the arms are moved toward the area that is in the middle of his Sternum. This is the single "best" angle of humeral motion, for engaging the greatest number of Pectoral fibers at one time.

It should also be mentioned that the **direction of the Pectoral <u>fibers</u>** also lend us a clue, as to what would be the ideal direction of anatomical motion for that muscle. In this particular case, the Pectoral fibers run parallel with the origins of Clavicular, Sternal and Costal fibers, and the insertion on the humerus. However, this is true because the Pectoral fibers run in straight lines. Not all muscle fibers run in straight lines.

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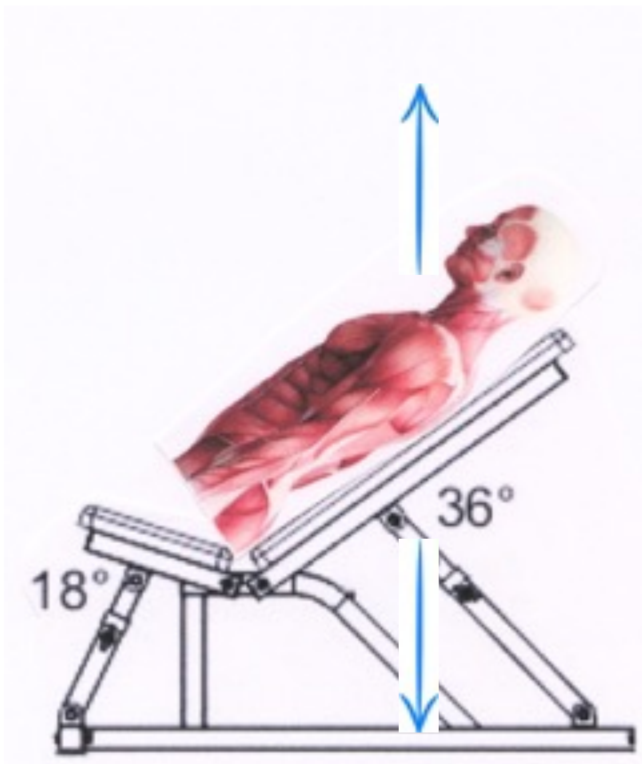
In the illustration below, we see a torso of a man on an Incline bench. I've placed a blue downward-pointing arrow, indicating the direction of resistance this man would be using. I've also placed an upward-pointing arrow - directly opposite the direction of resistance arrow - both of which run through the shoulder joint.



This is the "plane" through which the direction of resistance, and the direction of movement, both run - discussed in Chapter Seven. This is the "alignment" test. Notice that this plane is mostly NOT aligned with the origins of the Pectoral fibers - as it should be. This plane runs almost across the neck, where no Pectoral fibers are located.

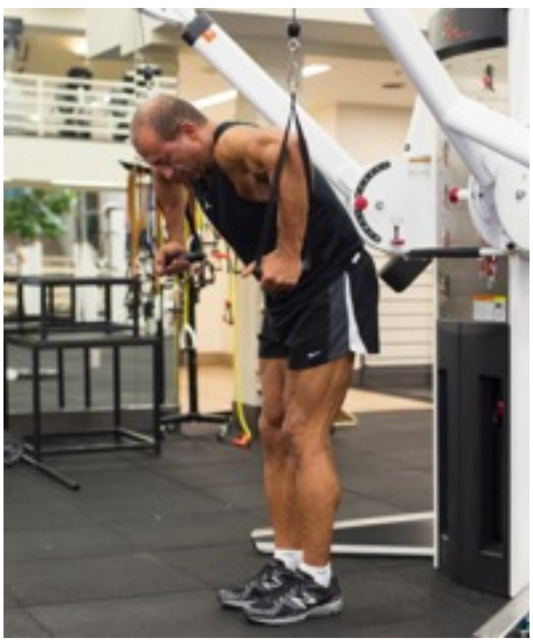
This bench is only set at a 36 degree angle. If the bench were set at a 45 degree angle (standard for Incline Presses), the "plane" would move even farther away from the

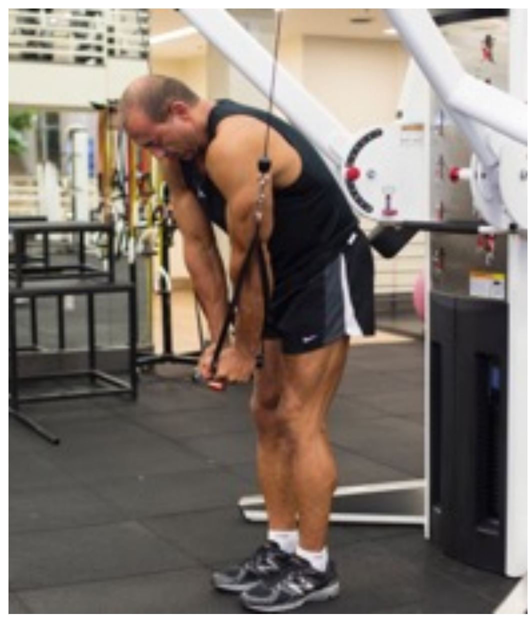
Pectoral fibers' origins. Yet people trying to work their "upper pecs" often think they should use a more steep Incline angle. In fact, the more steep the Incline angle that is used, the more that Pectoral participation is eliminated.

What about other angles for Pectoral muscle stimulation?

The only direction of humeral motions that make sense for the Pectorals, are ones that run parallel with the direction of the Pectoral fibers. That would be either "flat" angles, or various degrees of "decline" angles. However, it seems only two angles are really necessary - a "slight decline" (20 degree angle) and "very decline".

The "very decline" angle is best performed by way of cables. Otherwise, we'd have to position ourselves nearly "upside down" on a Decline Bench, in order to achieve this degree of "decline" angle - and that would be VERY uncomfortable.

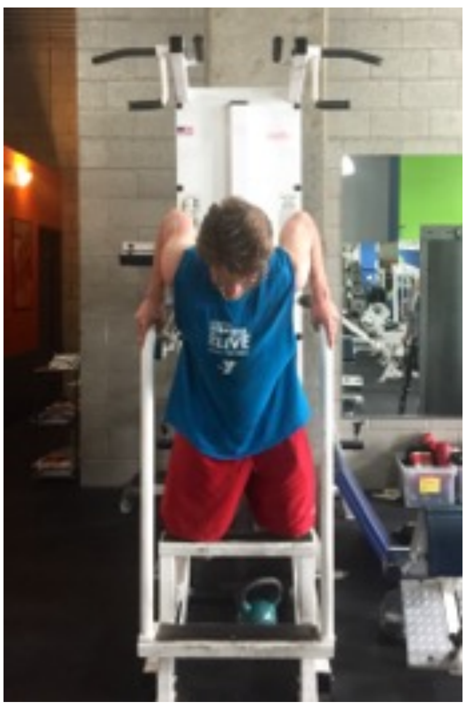
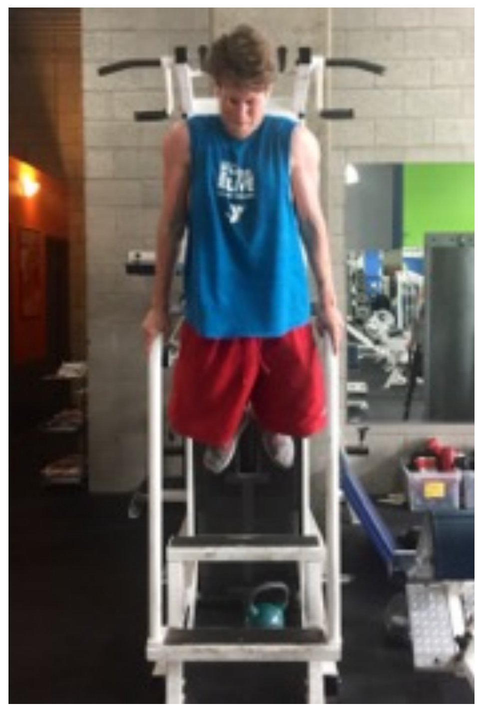




This exercise depicted above was mentioned in the previous chapter, as the "better" version of Parallel Bar Dips. It allows a slightly more angled torso position, as compared with Dips. This torso angle is better because it allows the resistance source to come more from behind, positioning the Pectorals more OPPOSITE the resistance. When doing Dips, the weight of the legs tends to tilt the entire body more vertically.

This exercise (*Extreme Decline Cable Press*) also allows the upper arms to go out to the sides, laterally (in the stretch position), in the stretch position - and then inward, toward the centerline of the body - in the contracted position. This is essentially impossible with *Parallel Bar Dips*.



Also, this exercise allows for more variable resistance options. One can select a weight that allows for as many as 50 repetitions, or as few as 6 repetitions, and everything in between.

Decline Dumbbell Press (below) and the exercise above - "*Extreme Decline Cable Press"* - are the best two exercises for the Pectorals.




They provide the correct anatomical motion, and they provide the ideal direction of resistance. One could even argue that the cable exercise above offers a slightly better direction of resistance than does the Decline Dumbbell Press, because the direction of resistance is also slightly “outward” (lateral) - rather than straight back. This creates a slightly better resistance curve - providing a little less resistance at the beginning of the movement (which is good in this case, because of the Mechanical Disadvantage), and a little more resistance at the point of contraction. But both are excellent exercises for the development of the Pectorals.

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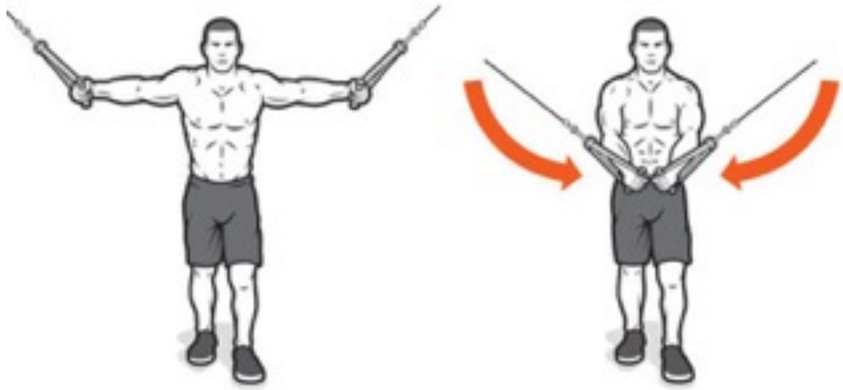
An exercise we commonly see performed in gyms as part of a Pectoral workout is the “*Cable Crossover”* illustrated below. However, because the resistance comes from so far laterally, it creates a resistance curve that provides too much resistance at the conclusion of the range of motion (point of contraction), and not enough resistance at the beginning of the range of motion (point of elongation).



“Early Phase Loading” requires that the resistance be greater towards the beginning of the range of motion - certainly during the **first half** of the range of motion. This is because that’s where skeletal muscles usually have the greatest strength capacity.

The humerus is the operating lever for the Pectorals, and it’s also the “primary lever”. The forearm is the “secondary lever”, in this case. It is usually preferable for the secondary lever to be “neutral” (parallel with resistance) throughout the entire exercise, although it’s acceptable if it leans “out” a little bit. But during *Cable Crossovers*, it leans “out” quite a lot. It becomes a fully “active” lever almost immediately (the early part of the range of motion), thereby loading the Biceps almost as much as the Pecs.

The result of these two factors is that the *Cable Crossover* ends up insufficiently loading the Pecs during the Early Phase of the range of motion, and excessively loading the Pecs during the latter part of the range of motion, plus energy is wasted loading the Biceps unproductively. The direction of movement is good - starting at shoulder height and then angling downward, as the arms move forward and inward (toward the Sternum). But the direction of resistance is much less than ideal.

I would rate the *Cable Crossover* a “5” (on a scale of 1 to 10) for benefit and efficiency. It’s not a terrible exercise, but certainly not one of the better exercises.

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Flat Bench Press and *Decline Bench Press* (**any barbell exercise used for the Pectorals**), are compromised because they have two problems related to “range of motion”. They stop far short of Pectoral contraction at the top of the movement because the hands are “stuck” on the bar. This prevents the humerus from finishing its final 20 degrees of the range of motion. Either an incomplete range of motion is ALWAYS good, or it’s not. If we “forgive” the incomplete range of motion of a Bench Press, we would need to also “forgive” an incomplete range of motion on every other resistance exercise. But we know that is not acceptable.

Below, we can see the difference in ending positions, between using a barbell and using dumbbells.

Also, if the bar is brought down "all the way" to the point where it touches the chest (as is customary), the upper arm bones would be brought down too far. This would create a dangerous degree of stretch in the Pectorals (when the weight is near maximum, due to the humerus' perpendicular angle) - greatly exacerbating the Mechanical Disadvantage that occurs in the Pectoral stretch position. This can be seen in the illustration below.

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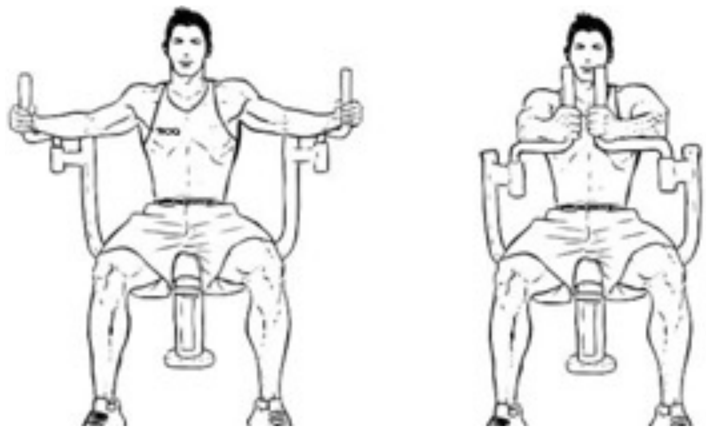
The *Butterfly Machine* (shown below) is not bad, but certainly not great. There are several versions of this machine - some are better than others. The ones that move the arms in a slight **decline** direction are better than those which move the arms straight forward. The position of the elbows matters as well. They should be held up, in line with the direction of movement. If they are allowed to drop - to be positioned lower than the hands - than there will be an automatic "external rotation" force on the shoulder joint, due to misalignment. This was discussed in Chapter Seven.



The better Butterfly Machines will also have a “cam”, which will provide more resistance at the beginning of the range of motion, and a gradual diminishment of the resistance as the range of motion nears its completion. This would comply with “early phase loading”.

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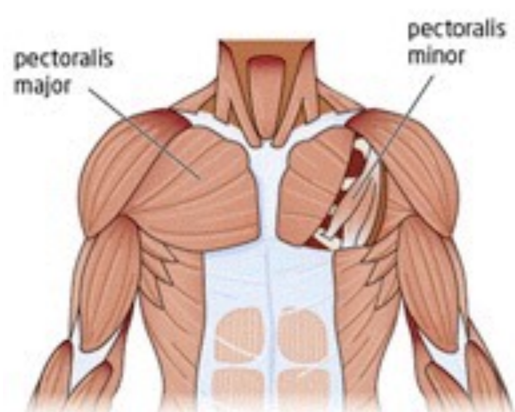
Pectoralis Minor

The Pectoralis minor is not commonly discussed, because it is not considered a primary muscle, nor a physique muscle. In fact, it is arguably not even a “voluntary” muscle. We cannot control it deliberately, because it does not cross a joint we can intentionally move.

It lies **beneath** the Pectoralis major, so it cannot be seen (except during surgery) - regardless of how lean one is. Since we cannot control it, it is not a muscle that can be deliberately worked, nor would there be any benefit in doing so.



Its origin is on the 3rd, 4th and 5th ribs - and its insertion is on the coracoid process of the scapula. **It does not tie into the humerus at all** - so it does not pull on the humerus (the upper arm) - the way the Pectoralis major does. Rather, it stabilizes the shoulder blade - pulling it forward against the thoracic wall. Its contraction is involuntary, and works synergistically with other muscles. It does not have any capacity for growth. So the idea that one could "build up" this muscle, so that it would "push" forward the Pectoralis major (making them appear larger), is without merit.

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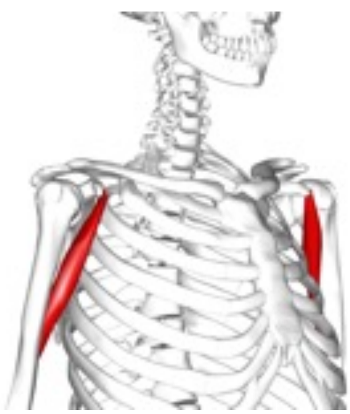
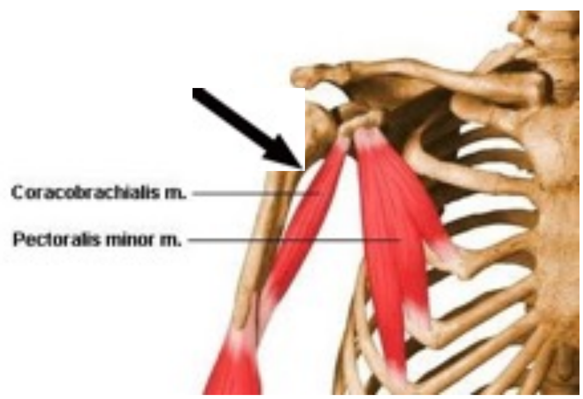
Coracobrachialis

This is a very small muscle, which **crosses the shoulder joint**, so it participates in humeral flexion and adduction - movements during which the Pectorals and Anterior Deltoids do the primary work. This is why I chose to include it here, in the "Pectoral" section - even though it's hardly worth mentioning from the standpoint of physique development.





It helps pull the humerus forward, upward and slightly inward, and stabilizes the humeral head in the Glenoid socket. It's origin is also on the coracoid process (like the Pectoralis **minor**, above), but instead of inserting onto the ribs, it inserts onto the humerus. It is not a muscle that can be isolated; it only works in conjunction with other muscles - and only as a minor assistant.

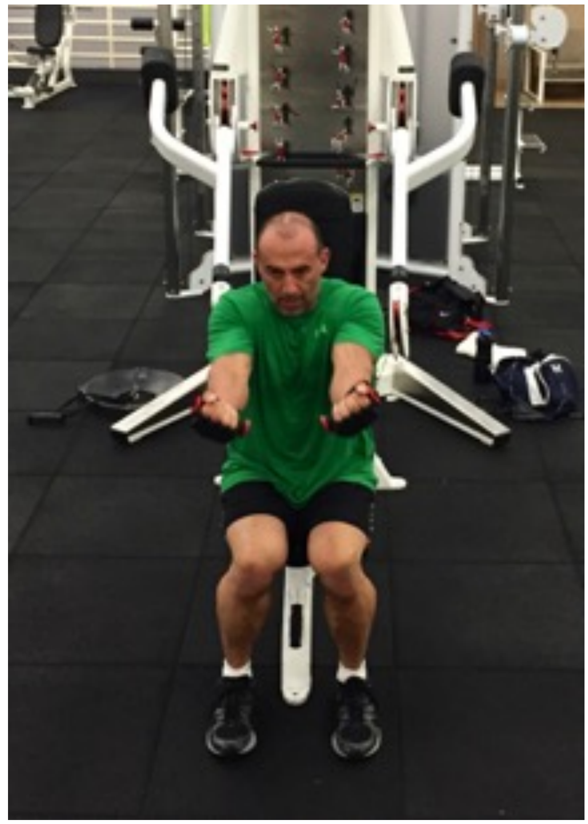
It can only be seen in rare cases, if one is lean enough. It **appears** as if it were part of the Biceps, even though it does **not perform elbow flexion** (because it does not cross the elbow joint). In the photo below (yes, my arm), it looks like a short rope, at the upper end of the biceps, right before it tucks under the outer edge of the pectorals.

Summary

The ideal anatomical motion(s) for the Pectoralis major are those that move the humerus from a position that is lateral to the body, toward the origins of the Pectoralis major, located on the Clavicles, Sternum and Ribs. This would primarily be considered “flat”, “slight decline” and “extreme decline” angles - if discussing exercises performed on a bench.

The terms “flat”, “slight decline” and “extreme decline” can also be used to reference an angle of humeral movement that mimics that angle - relative to the torso - even if NOT on a bench. In other words, an exercise performed while standing or while seated, could have the same angle of movement - relative to the torso - as would occur while lying on a standard bench. The illustration below depicts a “flat” angle of movement, because it is the same - relative to the torso - as a movement produced with free weights on a flat bench.

The Clavicular Pectoral fibers are effectively loaded and worked with "flat" and "decline" movements, but they also participate (quite a bit) when the Anterior Deltoids are worked (assuming a "good" exercise is used - like the one below).

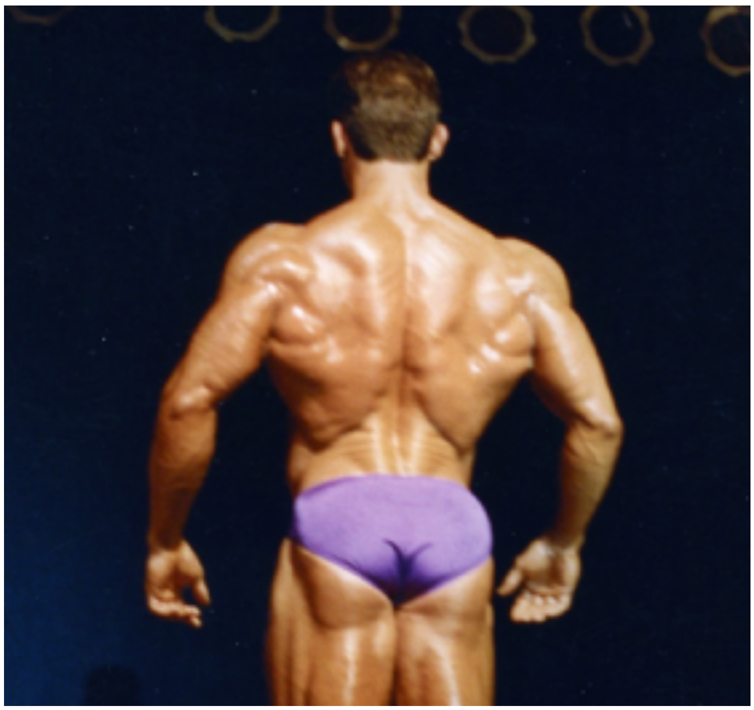


This is because the humerus is moving somewhat TOWARD the origins of the Clavicular fibers. Since the Anterior Deltoids and the Clavicular Pecs are side-by-side, they tend to work together, in movement that bring the humerus upward, from a position that begins at one's side.

Once the humerus has been raised to the other side of the Clavicle, it is no longer moving toward any Pectoral fibers. Therefore, **Incline** Presses of any kind - whether with barbell, dumbbell, cable or machine - provide almost no benefit whatsoever to the Pectoral fibers that are located on the upper part of the Sternum, and the Clavicular fibers.

Chapter Nineteen

Latissimus Dorsi
& "Upper Back" Muscles



In bodybuilding "jargon", people usually classify the Lats and other muscles of the upper back - collectively - as the **"back"**. For example, when someone asks, "What are you working today?", the answer would be something like "chest and **back**", or "**back** and biceps". However, it's important to **identify** the muscles of the "back", and understand their specific functions, in order to know which exercises are BEST for each part.

Most people know which part of the "back" is the Lats (Latissimus dorsi). However, most people in the gym, including most trainers, do not know - specifically - the names and functions of the other muscles on the upper back. How do I know this? Because virtually **no one** exercises the muscles of the upper back "correctly". This will be obvious in short order.

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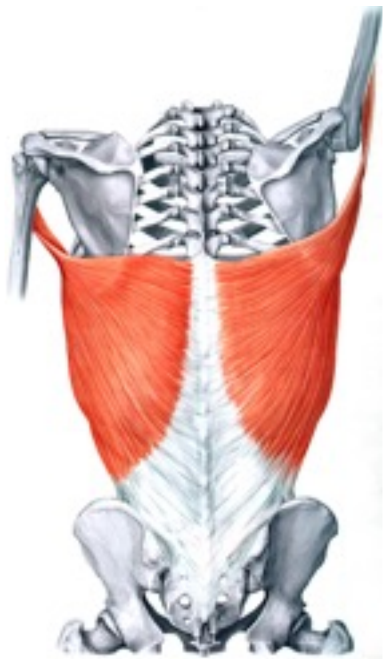
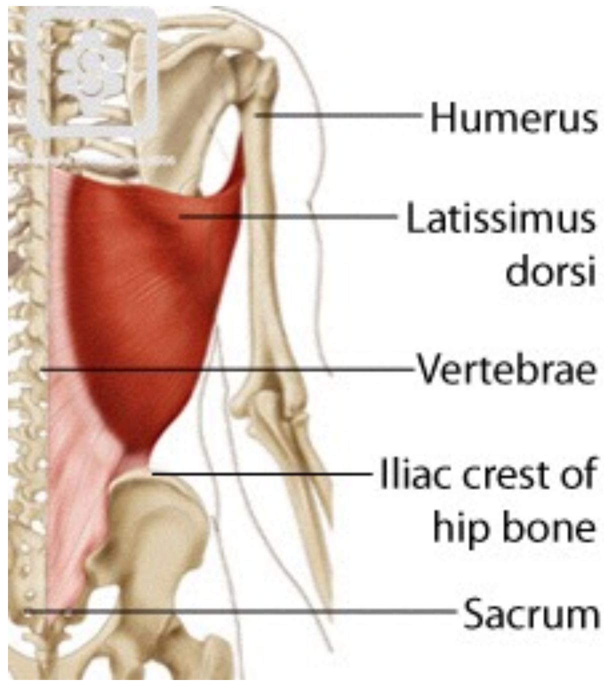
The **origins** of the Latissimus dorsi are located on the lower two-third of the spine (Thoracic 7 through Lumbar 5), and on the inferior 3rd or 4th ribs, and on the bottom tip of the scapula, and on the upper-posterior part of pelvis (the iliac crest). It's insertion is on the upper-inner part of the humerus, just below the humeral head.





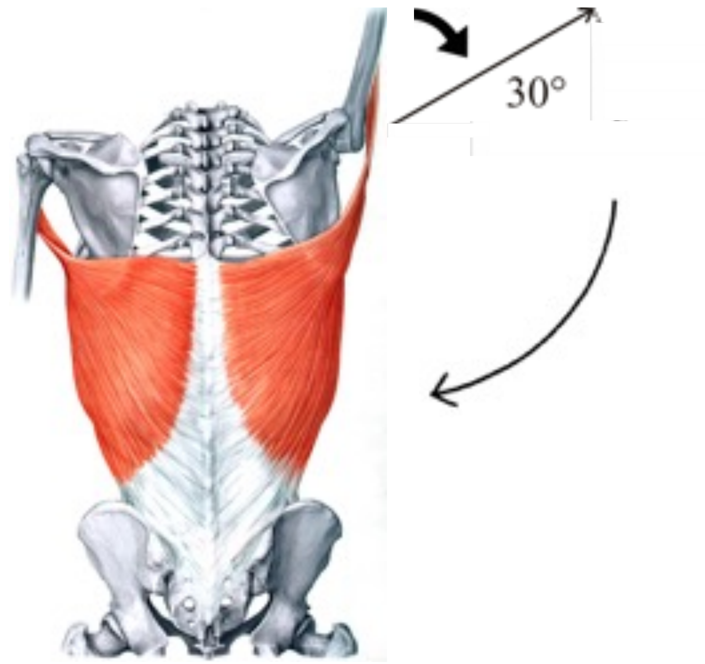
Common exercises for the Lats include Chin-Ups, and various types of pulldowns (wide grip with a straight bar, narrow grip with an A-bar handle, etc.), as well as various rowing movements (One Arm Dumbbell Row, Cable Row, etc.).

Using our three "clues" - the origin and insertion of the muscle, the direction of the muscle fibers, and the apparent design of the joint involved - let's examine what the ideal anatomical motion for the Latissimus dorsi is.

The most obvious clue is the direction of the Lat fibers. As you can see, they are mostly diagonal. That alone would suggest a diagonal movement, and a diagonal direction of resistance.

The second most obvious clue is the origin and insertion of the Lats. They are mostly all on the spine, and on the upper-inner part of posterior pelvis. Since "muscles always pull toward their origin", the ideal anatomical motion of the Lats would be a movement that causes its operating lever (the humerus / upper arm bone) to move inwardly, **toward the spine**, and **toward the upper-inner part of the posterior pelvis**.

That should spur the question, “FROM which direction should that motion come?”. Naturally, it should come from the **opposite** direction from whence it came. Again, this points to the direction of the Lat fibers. The movement should BEGIN from a point that is parallel with the Lat fibers, and **opposite** the muscle origins.



In the illustration above, I’ve place a 30 degree protractor line I’ve alongside the shoulder joint.

Now, notice that (in this illustration) the right humerus is significantly higher than that 30 degree angle line - it’s pointing almost straight up. As a result of this, the Latissimus is only able to pull on the humerus, from an extremely parallel angle. That creates an extreme Mechanical Disadvantage. In fact, from this angle, the Latissimus is **unable** to pull the humerus TOWARD its origins - because it must first move the humerus AWAY (outward, rather than inward) from its origins. That drastically increases the force requirement, to the point of inviting an injury.

Once the humerus passes that 30 degree mark, its trajectory will be more inward - toward the Latissimus origins.

So, the first thing that should be avoided is allowing the humerus to start any higher than that 30 degree angle mark. This would avoid the strain of Mechanical Disadvantage which occurs when the humerus is so high - and allows the humerus to begin moving toward the muscle origins, right from the start of the movement.

Therefore, the **ideal anatomical motion** for the Lats would be a movement that has the humerus (upper arm) beginning at that 30 degree mark (approximately), and then moving downward and inward, toward one's side (actually, toward the spine, until the torso stops that trajectory). This allows the humerus to move directly away from the spine during the eccentric phase of the repetition (for Latissimus elongation) - and then downward and inward, toward the muscle origins on the spine (for full Latissimus contraction).

This would represent the most pure, most natural Latissimus function. Other movements may require a degree of participation of the Lats. However, other movements that do not move the humerus laterally (up to 30 degrees from the shoulder) during the eccentric phase, and directly inward (as far as possible) during the concentric phase, would not engage the Latissimus as completely, nor as efficiently. So they would not have the same degree of productivity.

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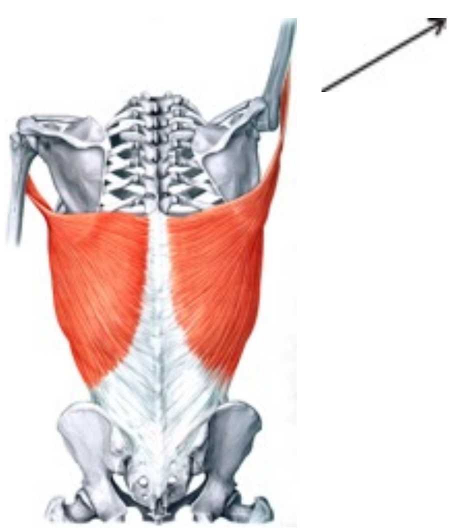
Ideal Direction of Resistance

As you know, the direction of resistance plays a role in determining the "resistance curve" of an exercise. It also plays a role in alleviating (or exacerbating) a Mechanical Disadvantage.

The Latissimus attachment is similar to that of the Biceps. When either of these muscles is elongated, it's only able to pull on its operating lever from a parallel angle. The increased force requirement of this degree of mechanical disadvantage is approximately 6X greater than normal. Therefore, in both cases - when working the Biceps or the Lats - it's **better** to provide a direction of resistance that is mostly parallel to the operating lever, at the beginning of the range of motion.



For the Lats, this means setting up a cable that pulls from an angle that is approximately 30 degrees from the shoulder (the joint which operates the Latissimus dorsi) - laterally.

As the operating lever (the humerus) moves downward and inward - becoming more perpendicular with the cable (the direction of resistance) - the Latissimus is able to pull on its operating lever from more perpendicular angle (mechanical advantage). This balances out the resistance curve nicely. We get less resistance when have a mechanical disadvantage, and more resistance when we have a mechanical advantage.

Another benefit of this particular exercise ("*One Arm Lat Pull-Ins*") is that we are able to pull our upper arm down and in - **farther** - than we would be able to with a Lat Pulldown. This provides us with a **better range of motion**: less at the top, where it's risky - and more at the bottom, for a better contraction.

So, you can see how changing from this exercise - with this particular movement, and this particular direction of resistance - to more of a straight downward direction of movement (and a straight upward direction of resistance) would be gravitating AWAY from the ideal. Of course, that would be a *Pulldown* with a straight bar. It "works", even if it isn't ideal. It would produce (in my estimation) about 70% of the "return on investment" (a rating of "7") - compared with a *One Arm Lat Pull-In*.

I would rate Chin-Ups a little lower (perhaps a "6"), since we can't control our body angle (relative to the pull of resistance) as well as we can with Pulldowns, and we also can't control the amount of weight we choose to use - even though it's essentially the same movement.

A narrow grip *Lat Pulldown* requires our arms to be in front of us, so it's impossible to pull toward the spine. Still, it does work the Lats to some degree - perhaps a "6" also. It has the advantage of allowing the user to control the weight selected better than *Chin-Ups*, but it involves the Posterior Deltoids a bit more than *Pulldowns* and *Chin-Ups*.

Rowing moves even farther away from the ideal Latissimus movement. Instead of pulling toward the spine, a Rowing movement requires us to pull straight backward. In fact, when doing a *One Arm Dumbbell Row* (below), we often rotate our torso such that we move the spine even farther away from the direction of humeral movement.

In the photos above, we can easily see the direction of this movement - straight upward. By the conclusion of the repetition (at the top of the movement), his humerus is literally moving AWAY form the spine - because of the torso rotation. Yes - the Latissimus is participating, but hardly. This movement is heading directly toward the origin of the Posterior Deltoid. The Teres major is also being worked here, but this a fairly small muscle, which we will look at very shortly.

Also, the direction of resistance is entirely wrong - when Rowing, with intentions to work the Lats. "Opposite Position Loading" requires (for maximum efficiency) that the direction of resistance be directly opposite the origins of the target muscle. Again the Latissimus origins are mostly on the spine. So, in the example above, that places them at approximately the 9:00 position at the beginning, and the 8:00 position at the end - relative to a 6:00 direction of resistance.

Rowing exercises might rate a “3” or a “4”, in terms of efficiency for Latissimus training.

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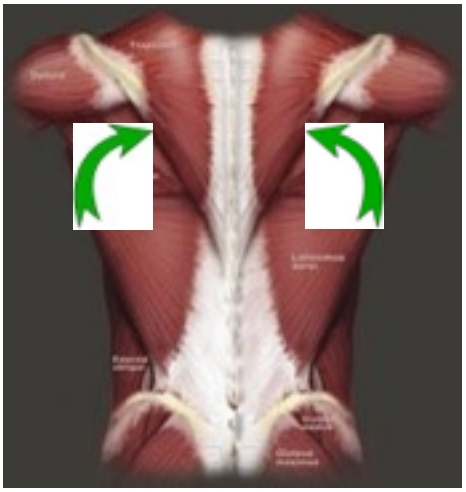
Muscles of the Upper Back

When most people look at a classic “Back Double Biceps” pose, like the one below, they don’t exactly know what they’re looking at, in terms the individual muscles. Yes - most people know what constitutes “the Lats”, and maybe even “the Traps”, but it usually ends there. For some reason, a lot of people throw out the word “Rhomboids”, but then either cannot tell you where they are, or assign them incorrectly (hint: They are not at all visible in a “Back Double Biceps” pose).

More importantly, most people - including most trainers and competitive bodybuilders - never **question** whether or not the exercises we’ve been told to do, are “maximally productive” for the development of those upper back muscles. In fact, most of the traditional “upper back” exercises are NOT as productive as you might think.

In the illustration **below-left**, we can see that the Trapezius is the **second most prominent muscle** of the back (green arrows) - second only to the Lats. It covers nearly a third of the entire back - from the base of the neck, down to the mid-spine, and from one scapula to the other. In the photo below-right, we can see what how significant the Trapezius (highlighted in red) is in the appearance of a muscular back. This is the well-developed back of legendary bodybuilder Mike Quinn.

Let’s look at the other muscles of the Upper Back - the **Teres major**, **Infraspinatus** and **Teres minor** - in order of prominence.

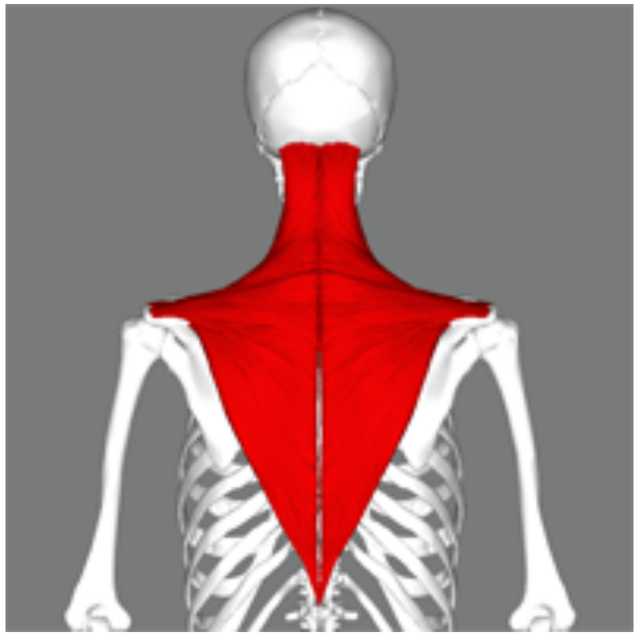
The **Teres major** is that triangular section, just above the outer part of the Lats. I’ve highlighted it in red, below-left. The Infraspinatus is seen below-right, in between the Trapezius, the Posterior Deltoid, the Teres major and the Latissimus.

Now that we know what these muscles are called, let’s look at what they do - in terms of anatomical movement. Then, we’ll ask ourselves the very important questions: “Are we doing the right exercises for these muscles?”. “Does Rowing work these muscles?”. “Do Pulldowns work these muscles?”.

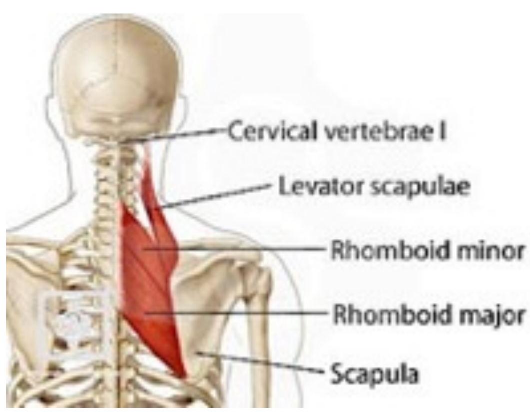
Middle Trapezius

The **origins** of the Trapezius are situated on the upper two-thirds of the spine, beginning at the base of the skull (the occipital bone), down to the lower thoracic vertebrae (T6 through T12). Almost all of its fibers then converge, and **attach** onto the scapula (the shoulder blade), as well as the outer portion of the clavicle (collar bone). **None of the Trapezius muscle fibers attach onto the humerus**. This is important to note, as you'll soon see.



The direction of the Trapezius fibers are indicative of the muscle's actions. The upper Trapezius fibers pull the scapula and the outer end of the clavicle, **upward**; the middle fibers pull the scapula **backward and inward**; and the lower fibers pull the scapula downward, backward and inward.

The Trapezius is assisted (mostly when pulling the scapula upward) by the **Rhomboid major** and **minor**, which lie beneath the Trapezius. This is why they are not visible, even when one is totally lean. The **Levator scapulae** also assists the Trapezius in pulling scapula upward.

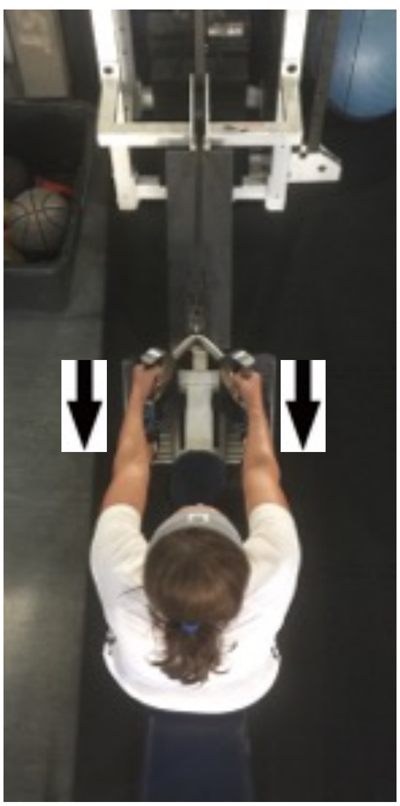


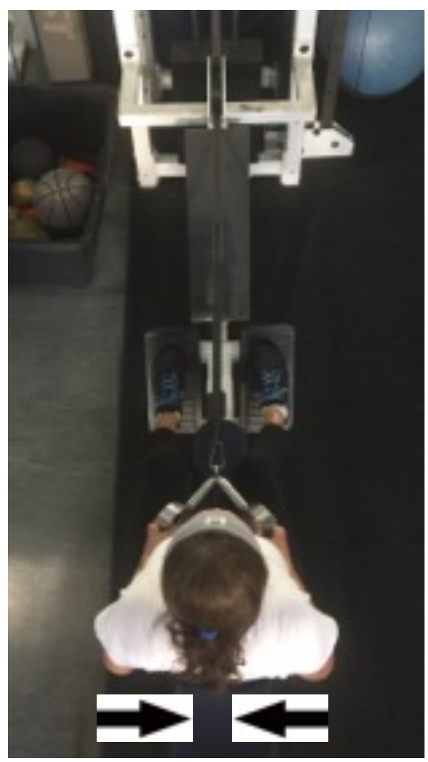
So, now that you know that the Trapezius - the most prominent muscle of the Upper Back - does NOT connect to the arms, how much benefit do you think the middle Trapezius gets when we perform a *Rowing* exercise?

Next time you're at the gym, watch people as they perform "Seated Cable Rowing", and "One Arm Dumbbell Rowing" and various Rowing machines. What you'll see is that the Rowing motion is 90% to 100% <u>arm</u> motion. Yet, the Trapezius plays NO role whatsoever in the arm-part of the Rowing motion. The middle Trapezius pulls the shoulders backward and inward - toward the spine. That is the Trapezius' primary function.

Certainly, some people try to "squeeze" the shoulder blades together when they perform Rowing exercises. But it is not the primary motion of a Rowing exercise - and many times ONLY the arms are moving. Very often, people **do not** pull their scapula back and inward. And if they do - it's STILL not good enough.

The reason it's not good enough to deliberately pull the scapula back, during Rowing exercises, is because the direction of resistance is still WRONG. Having one's scapula pulling inward (toward the spine), while the resistance (from Rowing) is pulling straight forward, is very difficult. And the heavier the weight a person uses on Rowing, the more one must focus on pulling straight back, rather than pulling "inward" with the scapula.





Due to the “straight back” direction of movement produced by Rowing exercises - as well as the typically “straight forward” direction of resistance provided by Rowing exercises - the muscles that get worked the most are the Posterior Deltoids (primarily) and the Teres major (secondarily).

(Note: Some people’s Posterior Deltoid development is attributable more to the fact that they do heavy Rowing, than it is attributable to the Posterior Deltoid exercises they do. This is due (in part) to the fact that Rowing loads the Rear Deltoids so much, and also to the fact that most people do not work their Posterior Deltoids as efficiently as they could. This will be discussed in Chapter 20.)

“Opposite Position Loading” requires (for maximum efficiency) that the direction of resistance come from a source that is directly opposite the origins of the middle Trapezius fibers. Since those origins are on the spine (the center of the torso), the resistance should come from a 45 degree side angle - and the motion should be mostly scapular. The emphasis should be on squeezing the shoulder blades together, with a lesser emphasis on pulling with the arms - and then releasing the scapula forward.

This exercise would rate a “10”, for development of the middle Trapezius. It is the ideal anatomical motion for these muscle fibers - which occupy a significant area of the upper back. And it provides the ideal direction of resistance, because it is directly opposite those fiber origins. You can clearly see this in the photos above.

A standard Low Pulley Rowing would load the Posterior Deltoids and Lower Back with 100% of the load - because these muscles are positioned directly opposite the forward pull of resistance). However, it would only load the middle Trapezius with 25% to 30% of the load - because the middle Trapezius’ origins are positioned at 3:00 / 9:00, relative to the direction of resistance.

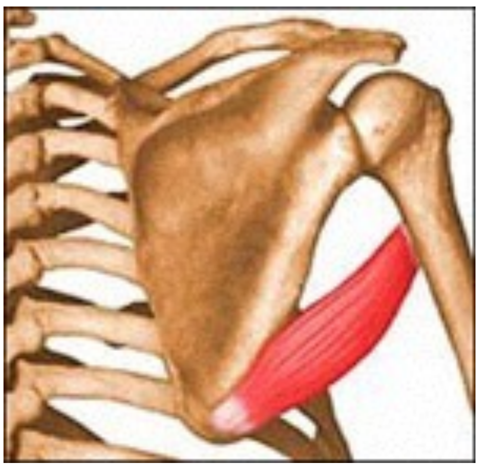
In comparison, this exercise above (“Scapular Retractions” with 45 degree Lateral Resistance) would load the middle Trapezius with 100% of the load, but would only load the Rear Deltoids with about 20% of the load, and Lower Back with **30% less** load that a standard Low Pulley Row. This is precisely what we want - more load on the target muscle and less load on the non-target muscles.

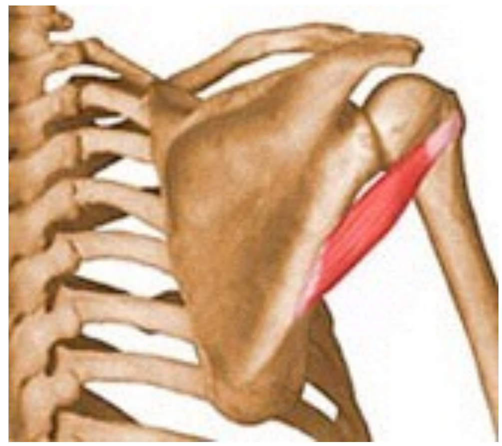
Incidentally, this exercise also works the Lats more than standard Rowing does. The reason for this is that the motion is toward the spine (where the Lat origins are), the resistance is opposite those origins, the Lats are connected to the arms, and the arms are also participating here. It’s not quite “as good” a Latissimus exercise as are *One Arm Lat Pull-Ins*, but it’s still better than standard rowing.

Teres major, Teres minor & Infraspinatus

The Teres major (below-left) is a small muscle that originates on the lower/outer edge of the scapula, and attaches onto the humerus - just below the humeral head.

The Teres minor (below-right) is an even smaller muscle - hardly visible as a “physique muscle” on most bodybuilders - situated alongside the Teres major. It originates on the outer edge of the scapula, and attaches on the posterior side of the humeral head.

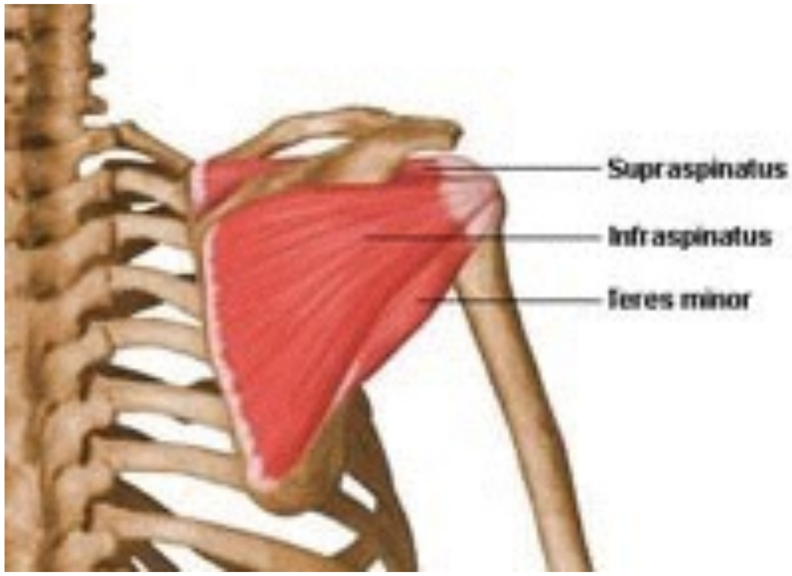




Because the Teres major (above-left) attaches onto the humerus a couple of inches below the humeral head, it is has some leverage on the humerus. In other words, it’s able to pull on the arm with some degree of effectiveness. Therefore, it participates in **ALL** Pulldowns / Chin-Ups / Lat Pull-Ins / Rowing exercises. It even works during Posterior Deltoid exercises.

However, the Teres minor (above-right) attaches so high on the humerus, that it is essentially no leverage on the humorous - it cannot actually “pull” on the arm. Therefore, it does not play much of a role in Pulldowns, Chin-Ups, Rowing, etc. It is primarily a shoulder rotator. It is one of the four “Rotator Cuff” muscles. It’s primary function is “external rotation” of the humerus - and it is not even the main “external rotator” of the humerus.

The Infraspinatus (below) is the PRIMARY external rotator of the humerus. As you can see in the illustration, it originates on the inner edge (posterior side) of the scapula, and then attaches onto the humeral head - just above the attachment of the Teres minor. When it contracts, it pulls (rotates) the humerus “externally”, pulling in the direction of its origins. It does not participate much in Pulldowns, Rowing, etc., beyond controlling the rotation (stabilizing) the humerus, during those motions.



This muscle, as well as the other “Rotator Cuff” muscles, will be further discussed in Chapter 25.

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So, when we work our “back” muscles, we are primarily talking about TWO primary muscles, which require two different movements.

1. The **Latissimus** is best worked with *Lat Pull-Ins* or - to a lesser degree - Pulldowns / Chin-ups.

2. The “Upper Back” is mostly comprised of the middle **Trapezius**, and is best worked with “Scapular Retractions”.

The **Teres major** already works whenever we perform Lat Pull-Ins, Pulldowns or Chin-ups. It assists the Posterior Deltoids more when humeral movements are straight back, but it assists the Lats more when humeral movements are inward - toward the spine.

The **Infraspinatus** is an external shoulder rotator. It will be addressed in Chapter 25, along with the other shoulder rotator muscles. It is best worked with an “external humeral rotation” exercise - rather than any kind of Rowing, Pulldowns or Pull-Ins.

To be clear, many people have developed very impressive Latissimus and Upper Back muscles by doing standard Chin-Ups, Pulldowns, T-Bar Rowing, Low Pulley Rowing and One Arm Dumbbell Rows. I am not suggesting these exercises do not produce results. I am suggesting that they are not maximally efficient. They require more effort, more time, more resistance and more risk of injury, as compared with the exercises (described above) that are more precise in the way they deliver load, and the way they contract the Latissimus and Upper Back muscles.

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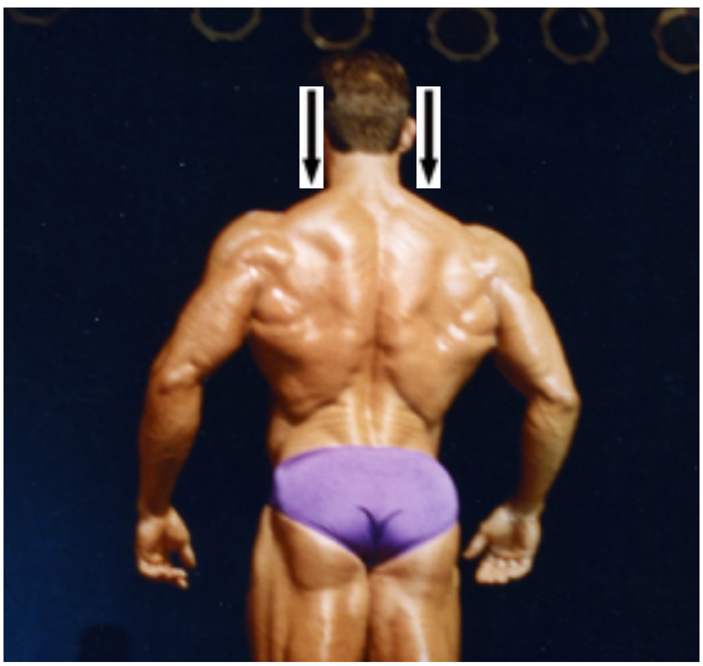
Upper Trapezius

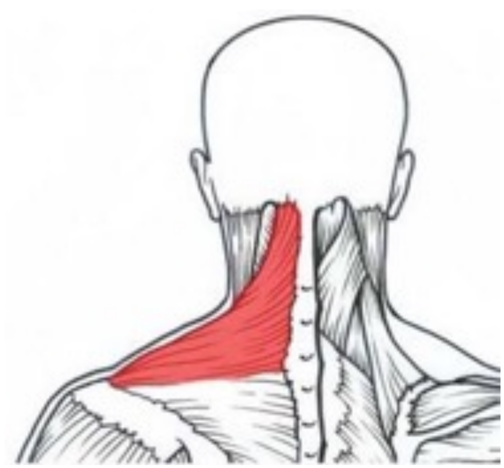
The upper Trapezius fibers are those located at the highest part of this muscle. These fibers play a role in the aesthetic of the developed physique, in the sense that it fills in the space between the neck and the shoulders - both when observed from the back, and well as from the **front**.



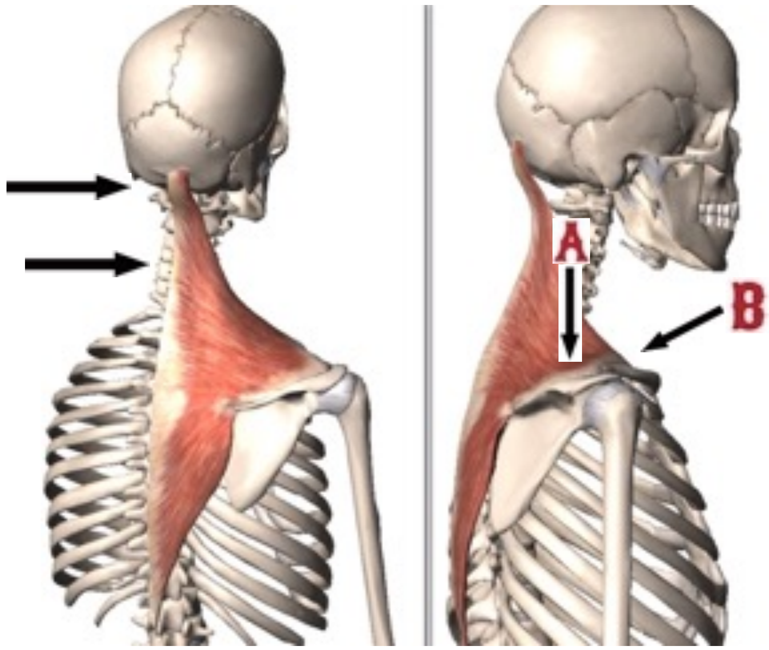
Depending on one's genetics, this muscle can either grow modestly, or considerably. The degree to which this muscle is not entirely within our control. All we can do is ensure that we are performing the correct motion, with the correct direction of resistance, with sufficient range of motion and sufficient intensity.

In the photo below-right, we see the more massively developed upper Trapezius flexed in a typical “Crab” pose. Below-right, we see the same pose, but with upper Trapezius that are much less massive. I have never been able to develop the thickness in this particular muscle that others have been able to acquire. Some say they “prefer” the aesthetics of a less massive upper Trapezius, while other believe “the bigger, the better”. Either way, our genetics play a role in this outcome.

Anatomically speaking, the upper Trapezius fibers are easy to work, because their ideal anatomical function is not complicated. They simply pull the shoulder carriage (i.e., scapula and clavicles) upward. So any “Shrugging” exercise will do the trick.

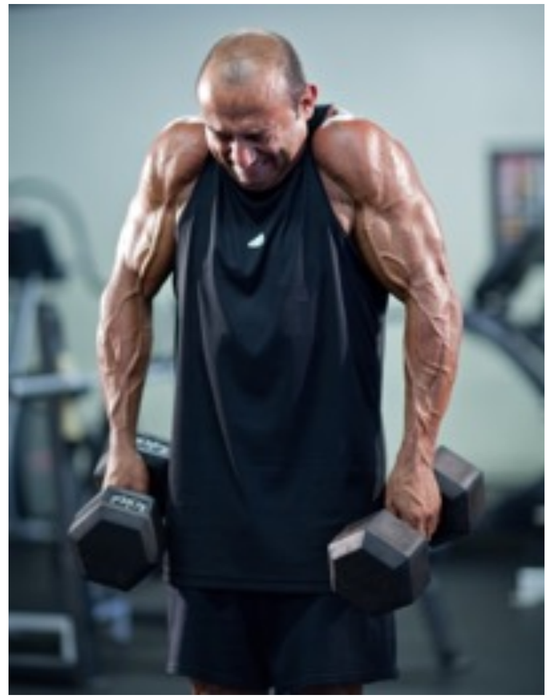


Here, in the illustrations below, you can easily see that their **origins** are almost all on the upper part of the spine (cervical). Some fibers originate at the base of the skull - no the occipital bone. Then, these fibers attach to the upper part of the ridge of the scapula (“A”), and the outer part of the clavicles (“B”). When the muscle shortens (contracts), it pulls the scapula and clavicle upward. Of courses, this drags the humerus up with them, because they're attached to the scapula and clavicle.

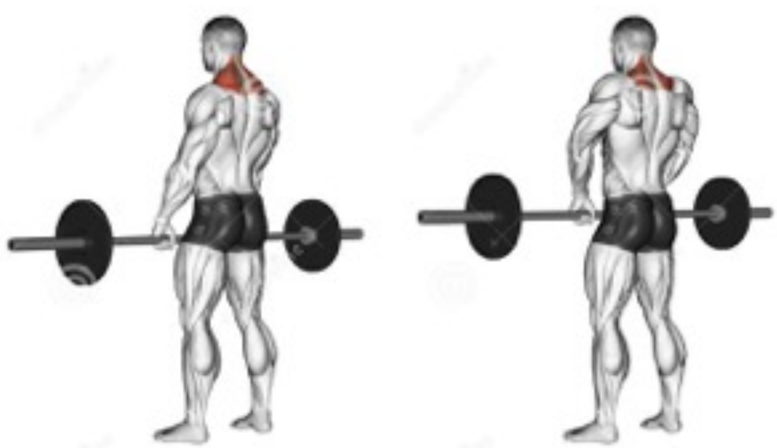


In these illustrations above, you can also see how the upper Trapezius fibers would naturally pull the scapula upward, the middle fibers would pull the scapula backward, and the lower fibers would pull the scapula in a downward-backward direction. The middle and lower fibers are best worked with an exercise that requires scapular retraction, while the upper Trapezius fibers are best worked with a simple upward-shrugging exercise. It is not necessary to pull in every single direction in which all of these fibers run.

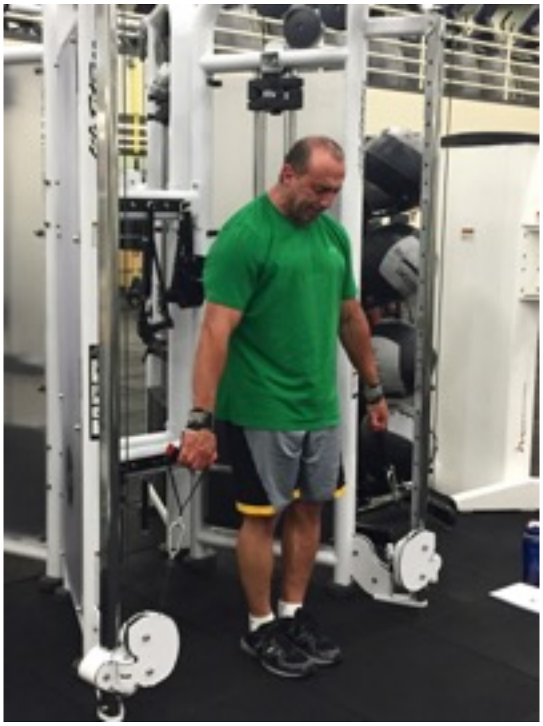
The most common Upper Trapezius exercise is the *Standing Dumbbell Shrugs* (below). This exercise is fine, and preferable over the Barbell Shrugs, because using Dumbbells allows the weights to be held alongside the torso / hips, which helps keep the spine stable.



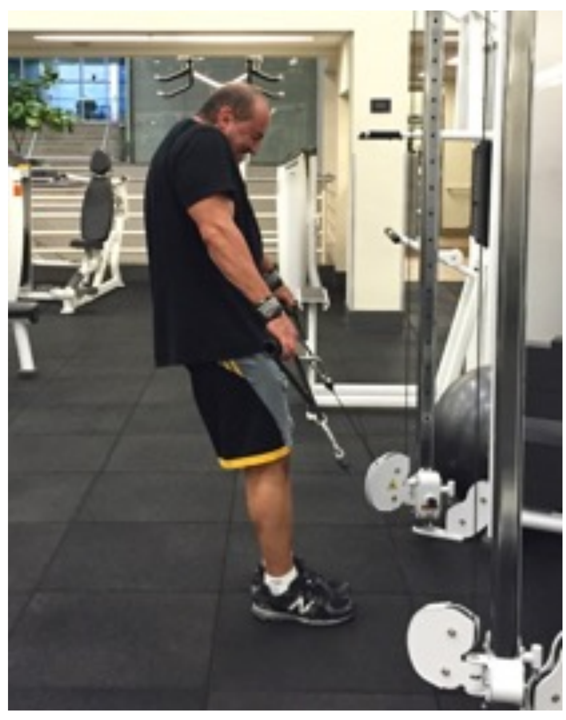
The illustration below shows a person using a barbell for *Shrugs*. However, as you can see, because the barbell must be held IN FRONT of the torso and hips, it will tend to pull the torso forward to some degree. This is not likely to be a problem, if the weight being used is relatively light. However, if the weight being used is "very heavy" it pull the torso forward, to a degree, and may over-load the Erector spinae of the back. There is no advantage in using a barbell for this exercise, so taking this risk is unnecessary.



My personal preference, in terms of "type of Shrug" for the Upper Trapezius, is the *Standing Cable Shrugs* (shown below) - for several reasons.

For one thing, I can keep the resistance alongside of me - as if I were using dumbbells - so there is no strain on the lower back. However, because I can use pulleys that are set wider than my shoulders, I don’t have to deal with dragging the dumbbells alongside my thighs and hips, which can be annoying.

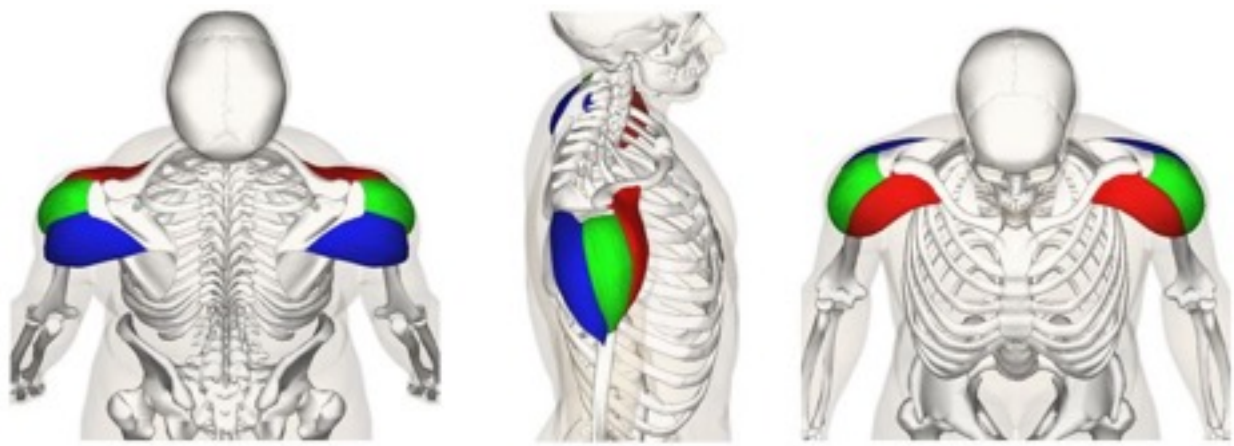
 

More importantly, I like being able to shift slightly forward, or slightly backward, depending on how I am feeling on any given day. This allows me to adjust for spinal comfort and also to “aim” the resistance straight upward, or **slightly** backward. If I step back (away from the pulleys - see photos below), it directs the resistance slightly more toward my **posterior** Trapezius fibers (due to “Opposite Position Loading”), as opposed to only the upper-most fibers. Notice that I can also lean back as I do this, which is NOT possible while using a barbell. This allows me to protect my lower back, while simultaneously directing the resistance a little more toward the posterior fibers.

It’s not necessarily “better” to direct the resistance more toward the posterior Trapezius fibers, especially since those are already being engaged when doing Scapular Retractions. But it’s fun to play with this feature a bit, and - again - it helps find an angle that allows more lower back comfort.

Chapter Twenty

Deltoids
Lateral, Anterior & Posterior

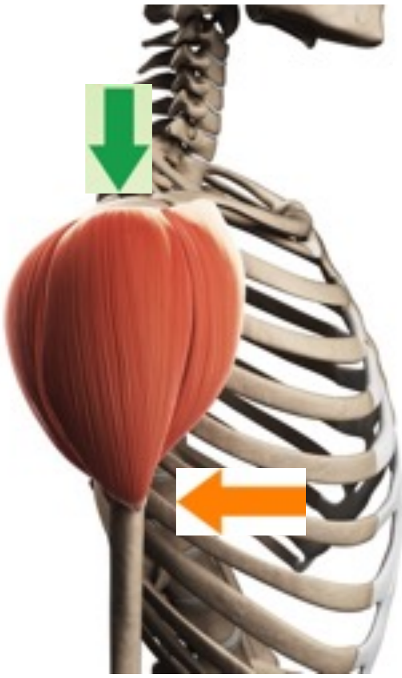


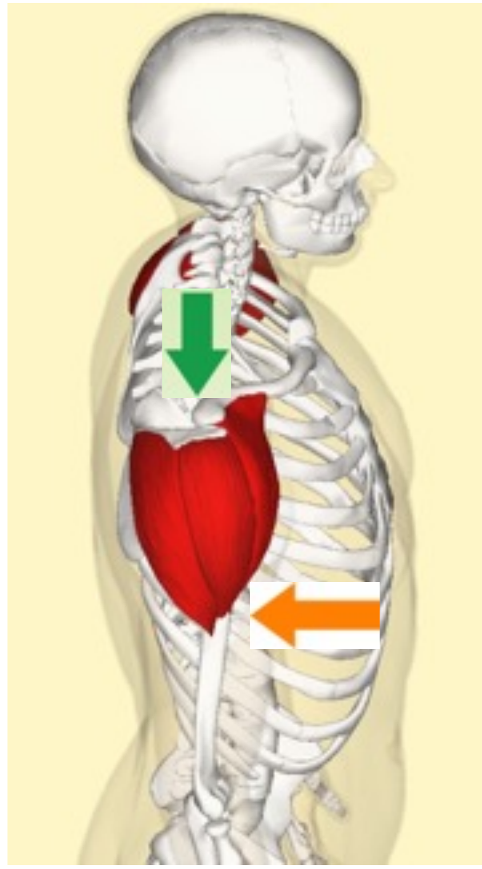
In gym jargon, the Deltoids are often referred to simply as “shoulders”, which includes the three Deltoid “heads”. Each of these heads has a separate function, technically speaking - although there can be some overlap. For example, a movement might involve the frontal part (Anterior Deltoid) and the side part (Lateral Deltoid). Another movement might involve the rear part (Posterior Deltoid) and the Lateral Deltoid. However, the Anterior Deltoid and Posterior Deltoid (of the same side) would never both participate in the same movement, because they are “antagonist” muscles. They move the humerus in opposite directions.

There are a number of exercises that are typically used to work the three parts of the Deltoids. Unfortunately - as you’ll soon see - most of those exercises are NOT entirely efficient for loading and contracting the muscle, nor entirely safe for the shoulder joint.

Let’s begin by first identifying the origin and insertion of the **Lateral Deltoid**, and establishing what would constitute the “ideal anatomical function” for this muscle.

The **Lateral Deltoid** originates on the outer edge of the Acromion Process (of the scapula) and its insertion is on the Deltoid Tuberosity of the humerus.

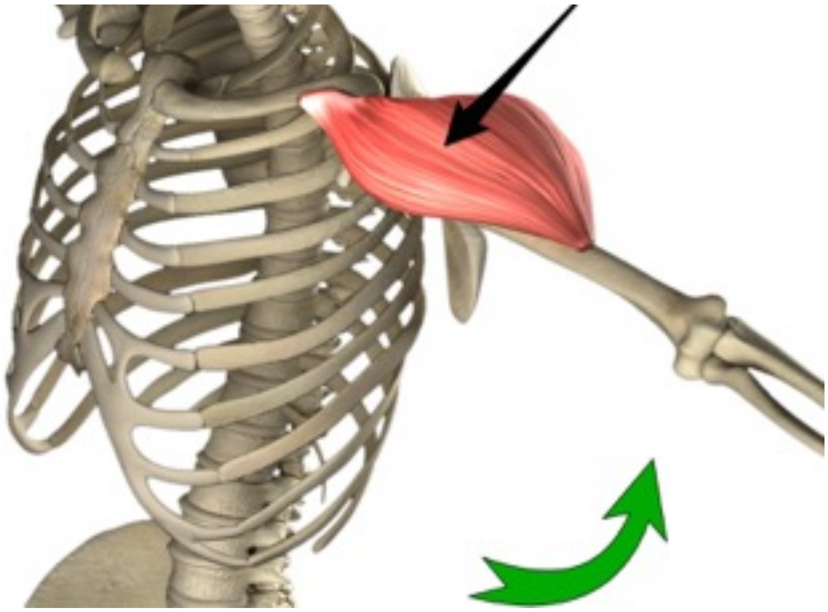




On the illustration above-left, the green arrow is pointing to the origin of the Lateral Deltoid, on the outer edge of the Acromion Process. The orange arrow is pointing to the insertion point on the humerus. The illustration below-right shows the same, from a slightly different angle.

Notice that the direction of the fibers of Lateral Deltoids is parallel with the plane that runs through the origin and the insertion of the muscle. When the Lateral Deltoid contracts (shortens), it brings the muscle insertion upward, toward the origin, thereby creating the movement known as “lateral abduction of the humerus” - raising the arm sideways. That motion is the “ideal” anatomical motion of the Lateral Deltoid. It produces the simplest, most natural engagement of the muscle, without any twisting or rotation of the humerus.

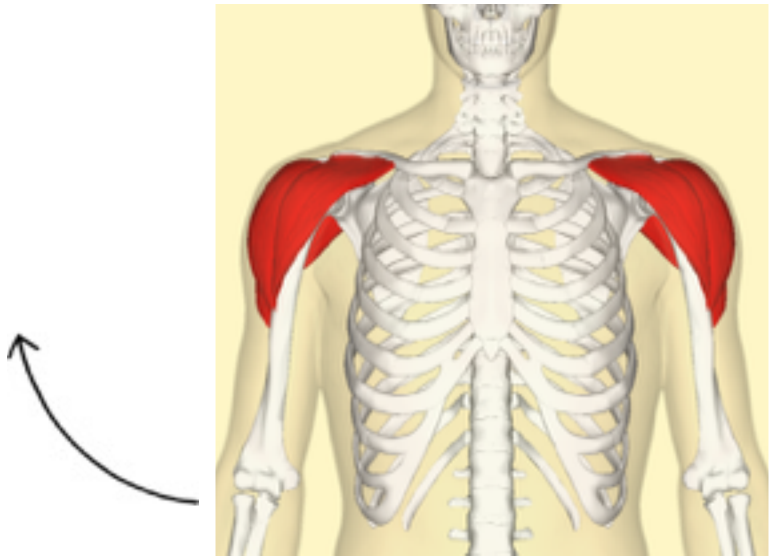
The ideal Range of Motion for the Lateral Deltoid is moving the humerus **from one’s side**, up to a point where **the humerus is almost perpendicular with the torso** (illustration below) - and no higher. By that point, the Lateral Deltoid is **fully** contracted - assuming the scapula (location of the muscle origin) has been held in place (not raised).



Actually, the Lateral Deltoid can be fully contracted even **before** the humerus reaches a perpendicular angle with the torso - provided the scapula is held down. However, if the scapula is allowed to raise up during the movement (which is what most people do - by "shrugging" their clavicle / scapula upward - then the origin of Lateral Deltoid **moves away from** the approaching humerus. Thus, the muscle insertion has to "chase" the retreating muscle origin - making muscle contraction more elusive.

Some people mistakenly believe that raising the arm **<u>higher</u>** than perpendicular with the torso, makes the "range of motion" more complete. It does not. The range of motion is complete when the muscle is fully shortened (contracted). That happens when the humerus is raised upward to an angle that is between 70 and 80 degrees of the torso - provided the scapula is not allowed to rise. Contraction is delayed - or avoided entirely - if one allows their scapula / clavicle to rise up (shrugging that shoulder up), while doing the movement.

You can test this for yourself. Simply have a friend put his (or her) hand on top of your clavicle / outer edge of the scapula / Trapezius, and hold it down firmly, as you perform a Lateral Abduction with that arm. You will discover that you can **only** raise your arm up to a point that is approximately 80 degrees from the torso - maybe even a little less. That is where the Lateral Abduction motion should end, if one is keeping their scapula down. That is where the Lateral Deltoid muscle fully contracts. Going beyond that point is not "better" - it does not provide a more complete range of motion for that muscle. Moving the humerus beyond that point results in shoulder impingement - the pinching of the Supraspinatus tendon, as it gets squeezed between the humerus and the acromion process.



The bottom end of the range of motion begins with the humerus right at one's side. There is no need to take the humerus farther inward. Some people believe that doing so increases the early part of the range of motion. In fact, doing so primarily causes the entire shoulder / scapula to roll forward, rather than causing more Lateral Deltoid elongation.

Raising the humerus laterally ("Side Raise") - with the range of motion described above and the appropriate direction of resistance - is all that is necessary to engage the Lateral Deltoid **perfectly**. There is no **better** movement for this muscle.

Any **other** movement that one might consider doing, should prompt these questions:

"How does that variation IMPROVE on the simple Lateral Deltoid mechanics of a Lateral Abduction?".

1. Does it position the Lateral Deltoid better, in terms of "Opposite Position Loading"?
2. Does it improve the alignment?
3. Does it improve the safety of the joint movement?
4. Does it allow a better Resistance Curve?

If an alternate movement does **not** do any of those things, than it is not a "better movement" for the Lateral Deltoid, nor for the shoulder joint. It is a "less natural" movement.

Overhead Presses and *Upright Rows* - two common exercises performed for the Deltoids - absolutely **compromise** the mechanics of the Lateral Deltoids. They position the Lateral Deltoid such that it is NOT directly opposite resistance, and they distort the alignment such that the origin and insertion of the Lateral Deltoid are **not** on the same plane as the direction of resistance and of movement. The *Overhead Press* excessively twists the shoulder posteriorly, impinges the Bursa and Supraspinatus tendon, and stresses the Infraspinatus. *Upright Rows* excessively twists the shoulder joint anteriorly, also impinges the shoulder, and also stresses the Infraspinatus.

Of course, a person is able to lift more weight when doing an *Overhead Press* or *Upright Rows*, but that is only because shorter levers are being used. The Deltoids are not necessarily getting any additional load. Doing theses exercises, along with *Side Raises*, is redundant at best. *Overhead Presses* and *Upright Rows* are much less efficient and have a higher risk of injury, as compared with Lateral Abduction. If wants to do more total sets, it's better to simply do more sets of Lateral abduction.

Lateral abduction of the humerus ("*Side Raise*") is the purest, most natural anatomical motion of the Lateral Deltoid muscle.   It moves the muscle insertion directly toward the muscle origin. There is **no need** to perform a motion that is more complicated, nor would there be any advantage in doing so.

Selecting the Ideal Direction of Resistance

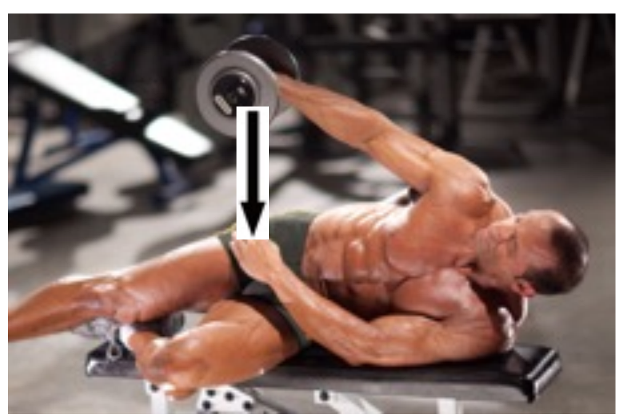
When we talk about a "*Side Raise*", the first exercise that usually comes to mind is the ***Standing Side Dumbbell Raise***. But that is **NOT** the best exercise for the Lateral Deltoid. Yes, the movement of the humerus is ideal. But the direction of resistance, is NOT ideal.

Below, we see a man doing a "*Standing Side Dumbbell Raise*". Since he is using free weight gravity (as the direction of resistance), and because he is standing vertically, the Resistance Curve of THIS exercise is "<u>Late</u> Phase Loaded" - rather than "Early Phase Loaded". It is lightest at the beginning of the range of motion, and heaviest and the end of the range of motion.

When he elevates his arms to the point where they are perpendicular with gravity (photo above right), his humerus is at the “maximally active” position, providing the most load to the Lateral Deltoids - but that is where the Lateral Deltoids are weakest. When his arms are down at his sides, his arms are parallel with gravity (“neutral”), so his Lateral Deltoids are not loaded at all - but that is when his Lateral Deltoids are strongest. The Resistance Curve of this exercise is the complete opposite of the muscle’s Strength Curve. Despite the motion being correct, the direction of resistance is not ideal.

What is needed INSTEAD is an exercise that provides “Early Phase Loading” - an exercise that provides the **most** resistance at the **beginning** of the range of motion, and the **least** resistance at the **end** of the Range of Motion.

The exercise below - *“Lying One Arm Side Dumbbell Raise”* - is one option.



You can clearly see how the resistance curve has been reversed. In this version of a Side Raise, the humerus is perpendicular with gravity at the beginning of the range of motion, and it's parallel with gravity at the conclusion of the range of motion.

The exercise below - *"Standing One Arm Side Cable Raise"* - is another option.

I prefer the Cable exercise above, because it allows me to use wrist straps (with D-Ring). Using these straps allows one to bypass the weaker muscles of the forearms and fingers. Ultimately, the Lateral Deltoids can handle much more resistance than the forearm extensors and fingers can accommodate. If one is using significant resistance on this exercise, the forearm and fingers will fatigue first, or become so achy during the exercise, that it will distract from the Deltoid work.

I typically compare the use of wrist straps on this exercise to Leg Extensions, where the resistance is applied at the ankle. Here, the resistance would be applied at the wrist.

Ideally speaking, the **height of the pulley** should be about as high as one's hips, so the cable is perpendicular with the forearm at the beginning of the movement. This would cause the resistance curve to be "heaviest" at the beginning of the range of motion (where the muscle is strongest), and "lightest" at the conclusion (where the muscle is weakest).

I realize that not every gym has an adjustable pulley like the one pictured above. Using the ***Lying Side Dumbbell Raise*** is a relatively good substitute for the *Cable Side Raise*, and it can be done anywhere. However, the forearms and fingers will likely become over-fatigued at some point, and would ultimately prevent one from using as much weight as the target muscle can handle.

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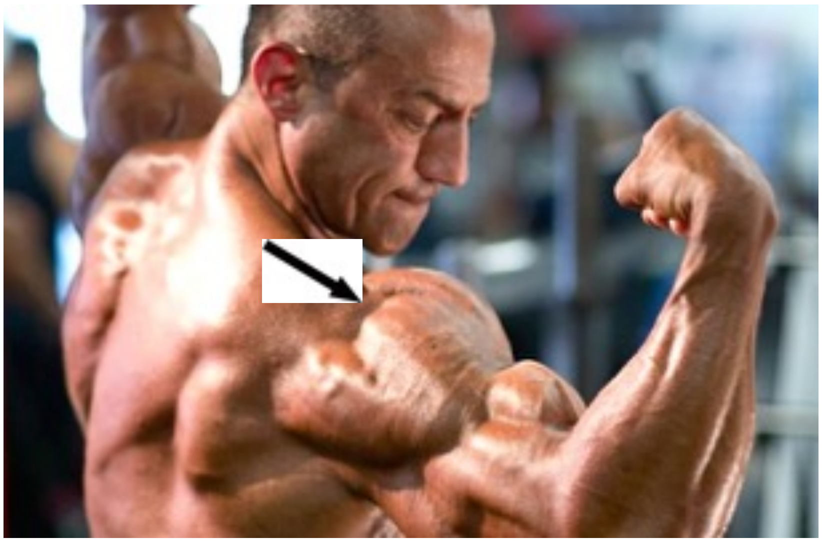
Using exercises that are not optimally efficient - like *Overhead Press* and *Upright Rows* - is perfectly acceptable for people who don't mind spending more energy than is necessary, don't mind incurring a higher risk of injury, and are more concerned with lifting heavy weights than they are with efficient muscular development.

Also, if a person prefers to keep their workouts more "fun", more casual and more flexible, then using exercises that rate lower than an "8" is fine. What's important, however, is to not delude ourselves into thinking that all exercises are equally productive, equally efficient or equally safe.



In the photo above, you can see that my Deltoid development is not lacking. Most people would automatically assume - seeing this photo - that my Deltoid workouts included *Overhead Presses* and *Upright Rows.* However, I have not done those exercises in many years. The Lateral Deltoid development you see in the photo above was achieved entirely with one single exercise - *Cable Side Raises*.

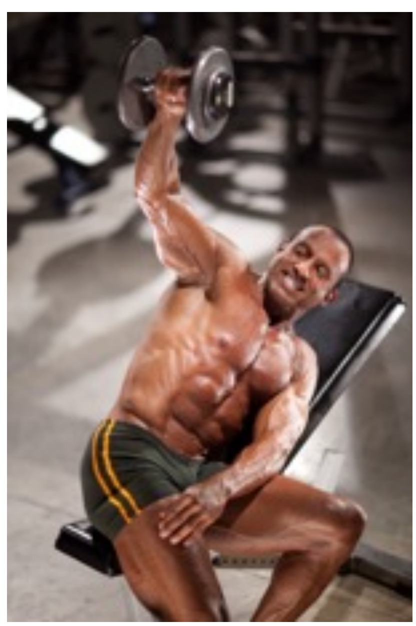
I typically do my first set for 50 reps (with light weight, of course). Then, I add a bit of weight, and do 40 reps, then 30 reps, then 20, then 15, then 12, then 10, then 8, and then 6 reps - adding weight each time (and resting a couple of minutes between sets). Sometimes I do two or three sets of 15, 12, 10 or 8. I typically end up doing about 10 sets in total. By the time I'm finished with this sequence, my Deltoids are "fried" (exhausted); they don't need any more work.

There are people who would argue that this is not the ONLY way to develop world class Deltoids, and then point to the many other bodybuilding champions who have used conventional methods. I agree - it's not the only way.

I am saying this is the **most efficient** way. I am saying (and proving) that doing *Overhead Presses* is **not** "essential", even though that has been the conventional wisdom for decades. My Deltoid development is as good, or better, doing 10 sets of this one exercise, as compared to the many people who do three or four exercises per workout - totaling as many as 20 sets - while straining their shoulder joints.

The **best** Lateral Deltoid exercises, in descending order, are as follows:

1. Standing One Arm Side **Cable** Raise, with pulley set at pelvis height
2. Lying (horizontal) One Arm Side Dumbbell Raise, on floor mat
3. Incline One Arm Side Dumbbell Raise - **below** (the lower the Incline angle, the better)



4. Standing (or Seated) Side Dumbbell Raise

When performing any kind of *Side Raise* exercise, one should always try to end the range of motion at the point where they "feel" the Deltoid contract. Even though we give guidelines as to **WHERE the arm should be** at the conclusion of the movement (e.g., 80 degree angle from the torso), the ultimate determinant of where the range of motion ends is the sense that the muscle has reached the point of contraction. This is no different than when we do Biceps Curls, or Triceps Pushdowns, or Leg Extensions. We should not abandon our sensory / kinesthetic connection to the exercise, relying only "external" cues, in regard to where the range of motion should end. Using both "internal" (sensory) and "external" (anatomical knowledge) cues, is best.

One of the great advantages of doing an "Early Phase Loaded" *Side Raise*, is that - since the resistance diminishes toward the end of the range of motion - the muscle contraction can be felt and held. This is not true when doing an exercise that is "Late Phase Loaded", like *Standing Side Dumbbell Raises*. Since that version is "too heavy" at the end of the range of motion, it's impossible to hold one's arm at the conclusion of the range of motion - assuming one is using a significant weight.

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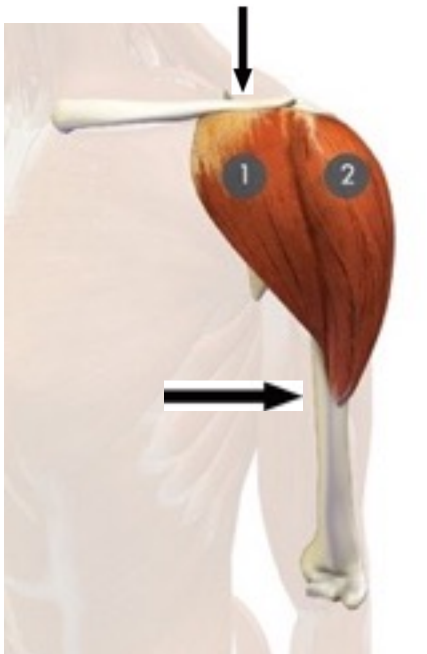
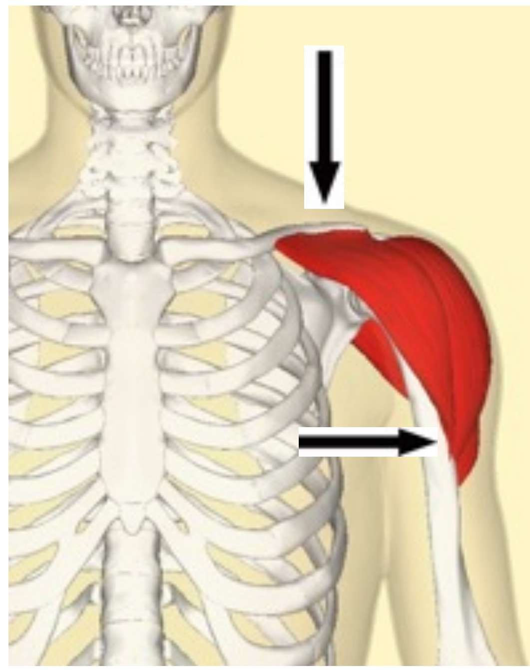
Anterior Deltoid

The Anterior Deltoid is the also known as the "Front Deltoid". As you can see in the illustrations below, it originates on the outer third of the Clavicle, and its insertion is on the Deltoid Tuberosity on the humerus (adjacent to the insertion of the Lateral Deltoid).





The Anterior Deltoid **participates** in any movement where the humerus is pulled forward - toward the Clavicle, which includes some chest exercises and also Overhead Presses. But the question is, "**What is the Ideal movement?**".

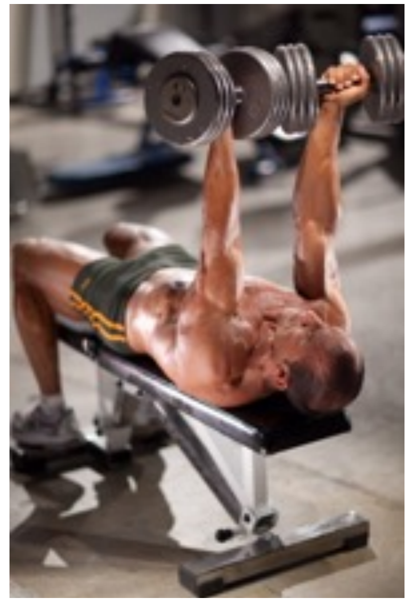
Again - following our guidelines ("muscles always pull toward their origin") - the first thing we'll do is imagine the insertion of the muscle being pulled directly toward the muscle origin, in as simple and straightforward a manner as possible. That would produce a movement that takes the humerus (starting from the point where it's alongside the torso) STRAIGHT toward the outer portion of the Clavicle.

This might make you think the exercise the *Standing Front Barbell Raise* is a "good" exercise for the Anterior Deltoids. However, there are two problems with this exercise.

The first is that the when the palms of the hands are facing downward, the humerus is rotated internally. This causes the <u>**Lateral**</u> **Deltoid** to face "upward" (i.e., is on top of the arm). This was discussed in Chapter 9 ("Opposite Position Loading"). Since the resistance is "free weight gravity" (i.e., pulling straight down), the **Anterior** Deltoids would **not** be directly "opposite the resistance", so long as the palms of the hands are facing downward. We must rotate the humerus externally, such that the palms of the hands are facing upward (or, at least a "hammer grip") - so the elbows point downward. This would rotate the Lateral Deltoids away from the "opposing resistance" position, and will shift the Anterior Deltoids INTO the "opposing resistance" position.

However, the second problem is the resistance curve - it's "Late Phase Loaded", instead of "Early Phase Loaded". This version of the movement provides insufficient resistance at the beginning of the range of motion (where the muscle is strongest) and took much resistance at the end of the range of motion (where the muscle is weakest). The muscle won't be challenged when / where it needs it most. This version also "invites" cheating (swinging / using momentum) to raise the weight up.

By changing one's body position (below), relative to the downward pull of gravity, the resistance curve can be reversed - making it "heavier" at the beginning of the range of motion (where the muscle is strongest), and "lighter" at the end of the range of motion.

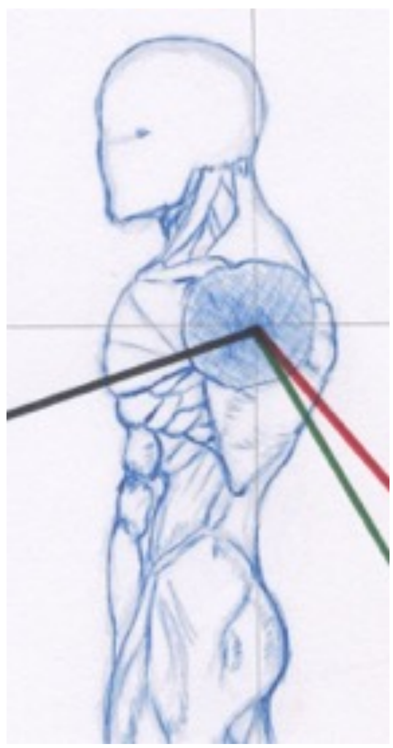
  

Focus your attention on the upper arm bone (the humerus). It's doing the exact same motion as the Seated Exercise above. That is the "ideal anatomical motion" of the Anterior Deltoid - but now the resistance curve matches the muscle's strength curve.

Note that the Anterior Deltoid ONLY pulls on the humerus, and does not "know" whether the elbow is bent or not. In other words, the Anterior Deltoid does not "know" whether the lever it's pulling on is shorter (with more weight) or longer (with less weight). It only knows how much load it's required to pull. A longer lever with less resistance, and a shorter lever with heavier resistance, might equal the exact same amount of net load, as far the Anterior Deltoid is concerned.

So, by performing the above exercise as "press", rather than with a straight arm, allows us to eliminate the involvement of the Biceps, which is not as strong as is the Anterior Deltoid.

As an alternative to changing YOUR body position relative to gravity, you can change the DIRECTION OF RESISTANCE - and stay upright. This version below achieves the same end result - the "ideal" anatomical motion for the Anterior Deltoid, but with Early Phase Loading. Notice the direction of the cable, relative to the upper arm lever. It is more perpendicular (to the humerus) at the beginning of the range of motion, and more parallel (to the humerus) at the end of the range of motion.

In the illustration above, I've drawn a red line where the range of motion would become approach being "excessive" (too much stretch) - especially if using heavy weight. The green line is the better, safer beginning point of the range of motion. The black line is the ideal ending point (point of contraction) for the Anterior Deltoids. Now compare this illustration with the photos above it. Of course, people have different degrees of shoulder mobility, so this may vary a bit. But, it's approximately correct.

Since the Anterior Deltoids originate on the Clavicle, and the direction of humeral movement is TOWARD the Clavicle, you'll have the added benefit of also engaging (to a slightly lesser degree), the Clavicular Pectorals. They originate on the Clavicles also, although the more on the inner part - closer to the sternum. By bringing both arms **slightly** toward the center, we can engage the Clavicular Pecs a little more, than if we brought the humerus more toward the "outside". But the Clavicular Pecs would engage either way.

So, the best Anterior Deltoid exercises, in descending order, are as follows:

1. Seated Cable Front Press (shown above)

2. Lying Dumbbell Front Press (also shown above)

3. Slightly Decline Dumbbell Front Press

4. Slightly Incline Dumbbell Front Press

5. Seated (upright) Alternate Dumbbell Front Raise (straight arm with Hammer Grip)

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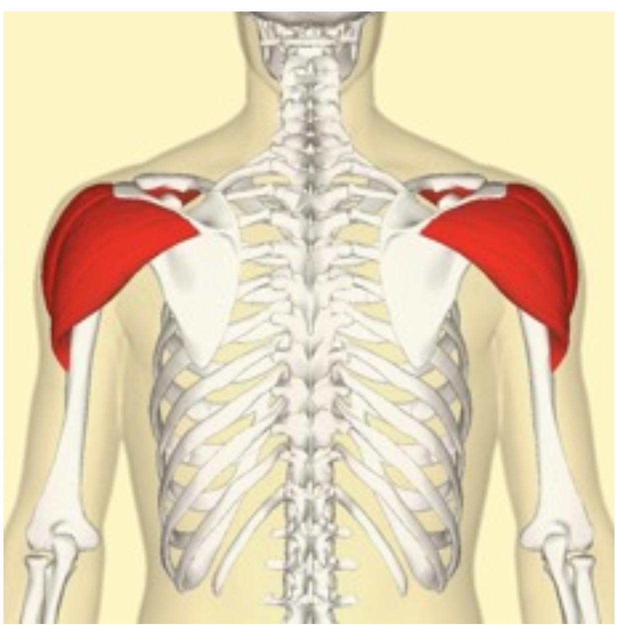
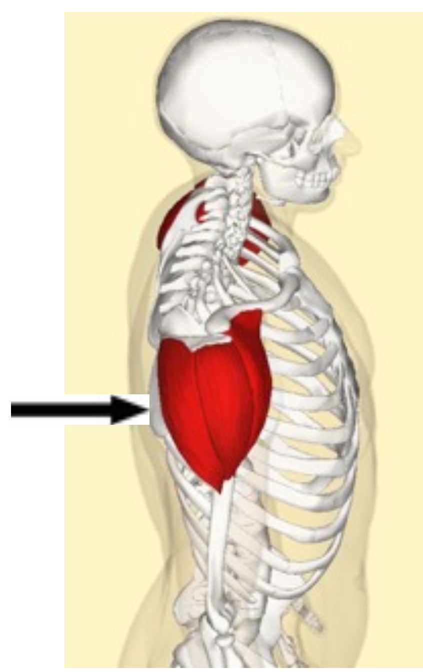
Posterior Deltoids





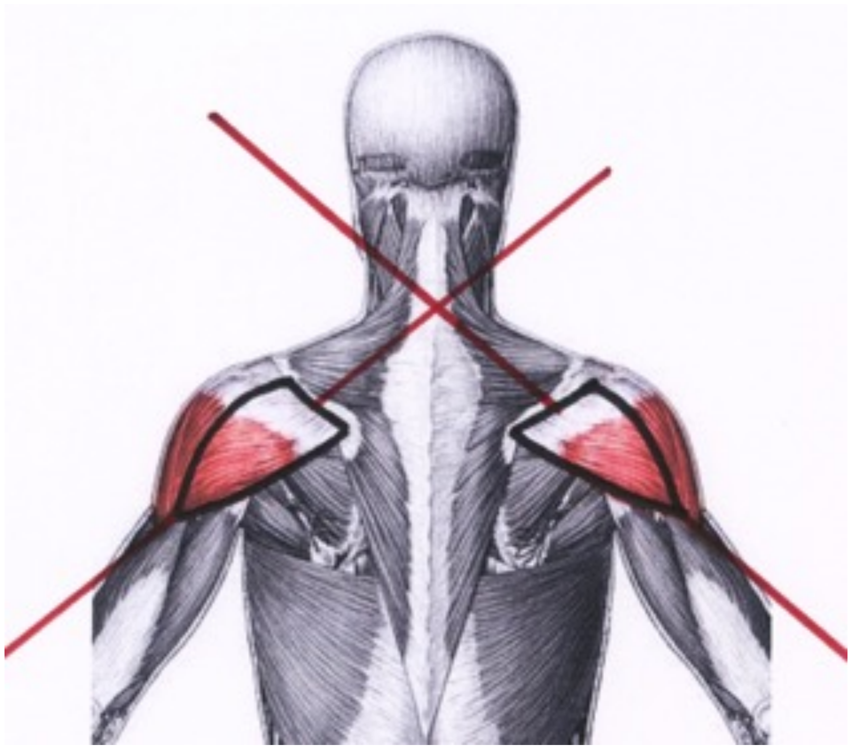
The Posterior Deltoids are also known as the “Rear Deltoids” or “Rear Delts”. As you can see in the illustrations above, they originate on the upper ridge (i.e., the “spine”) of the scapula (shoulder blade), and they insert on the Deltoid Tuberosity of the humerus. Below is another perspective, where you can more easily see where it originates and attaches (it’s the muscle labeled as “3”).

There are a couple of things worth noting, as we look at these illustrations (above and below). 1) When the arm is down at one’s side (as it is here), the Posterior Deltoid fibers run mostly vertically. 2) The upper edge of the scapula runs mostly horizontal to the torso, so the origins of this muscle line up horizontally along the spine of the scapula. It’s primary function is to pull the humerus back (posteriorly), and it also helps externally rotates the humerus.

Again, using our guideline of imagining the muscle insertion moving toward the muscle origin, in the most basic manner, we can see that the Posterior Deltoid pulls the humerus backward (from a frontward position) - as would be the case in “Rowing” exercises, for example. This was discussed in the Chapter 18, and also in Chapter 9 (“Opposite Position Loading”).

Again, the question is, “What would constitute the **ideal** pathway, and the ideal Range of Motion, for the Posterior Deltoid?”.

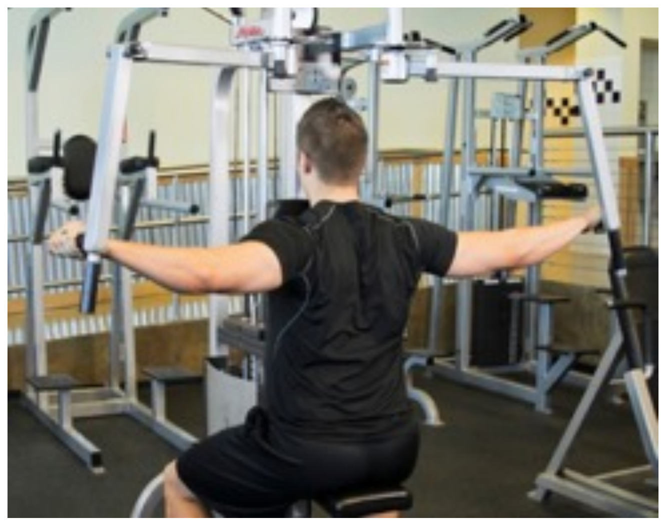
In the illustration below, I’ve drawn a red line straight through the origin and the insertion of both Posterior Deltoids. Remember in Chapter 8 (“Alignment”), we talked about how there should be alignment between the direction of resistance, the direction of movement, and the origin / insertion of the target muscle? Well, here it is - in black and white (and red). In other words, there is NO need to bring the arms up so that they are perpendicular to the torso. Simply pulling the arms straight back, with only a slight abduction of the humerus (moving the arms out to the sides a little bit), is all that is necessary to engage the Posterior Deltoids.



Despite the fact that we have all done “Posterior Deltoid Exercises” with our arms up, so they are perpendicular with our torso - it is entirely unnecessary. It does NOT improve the mechanics of the Posterior Deltoid function. In fact, one could argue that it compromises it.

Since the origins of the Posterior Deltoid are set somewhat diagonally on the ridge of the scapula, a humeral movement that moves toward that ridge from an angle that is perpendicular to it, makes the most amount of sense. Also, the shoulder joint is much more accustomed to operating with the arms low, than it is to operating with the arms held high. So, this performing Posterior Deltoid exercise with arms low (as shown above) is a much more “natural” movement.

From an evolutionary perspective, we can ask ourselves this question: “To what evolutionary need did our Posterior Deltoids adapt?”. Certainly there were no “Reverse Butterfly” machines for our Homo Erectus ancestors to use in the wild.

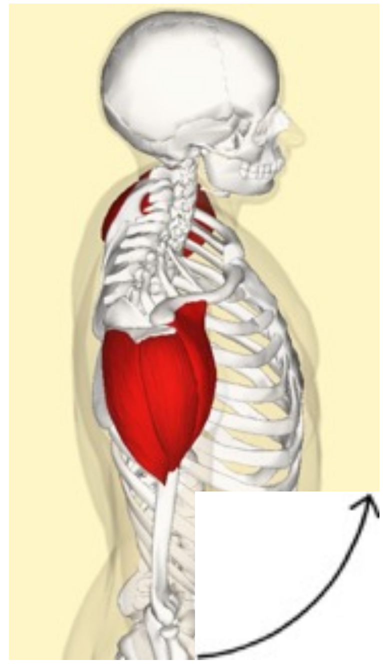


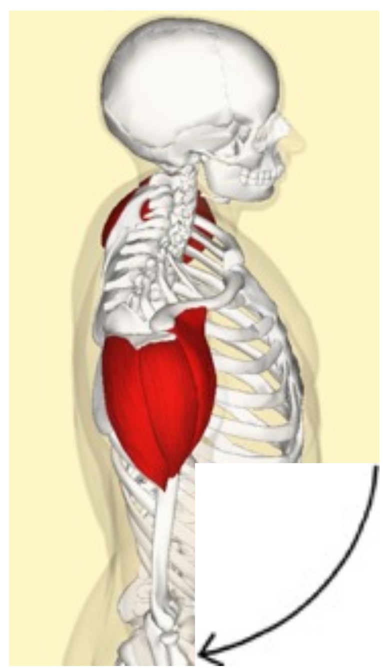
It seems obvious that our Posterior Deltoids evolved to allow our ancestors to pull objects backward, with arms low. The fact that the muscle insertion is lower than the muscle origin, suggests the simplest engagement of this muscle would be a movement that follows along that pathway: from the front, downward and then backward. It seems we’ve over-complicated this movement for years, unnecessarily.

There is simply no logical reason to perform Posterior Deltoid exercises with our arms UP, so that they’re perpendicular with our torso. There is no mechanical advantage to it whatsoever.

The “ideal” anatomical motion for the Posterior Deltoids begins with the arms inward (toward the center), but only at the height of the abdomen - then moving downward and backward, with a slight diagonal angle, parallel to the origin and insertion of the muscle.

Elongation occurs when the muscle insertion (on the humerus) moves away from the muscle origin. That would require a forward / inward motion of the humerus.





Muscle contraction occurs when the muscle insertion (on the humerus) moves toward the muscle origin - along the same plane. This would require the humerus to move downward and slightly outward, until the Posterior Deltoid is fully contacted.

It's actually much easier to feel the Rear Deltoid contract, when moving the arm along this pathway - as compared to the traditional (arms perpendicular to the torso) pathway.

The ideal **direction of <u>resistance</u>** would be one that comes from the opposing side, from an angle - **opposite** the position of the Posterior Deltoid. The right arm's resistance would come from the left - at approximately a 45 degree angle. The left arm's resistance would come from the right, at the same angle. This would create Early Phase Loading, and also provided alignment between the direction of resistance, the direction of movement, the origin and insertion of the Posterior Deltoids.

If you were to view this movement from overhead - from a ladder, for example - you would be able to see that the pathway of movement, and the cable, and the Posterior Deltoids, are all in perfect alignment.

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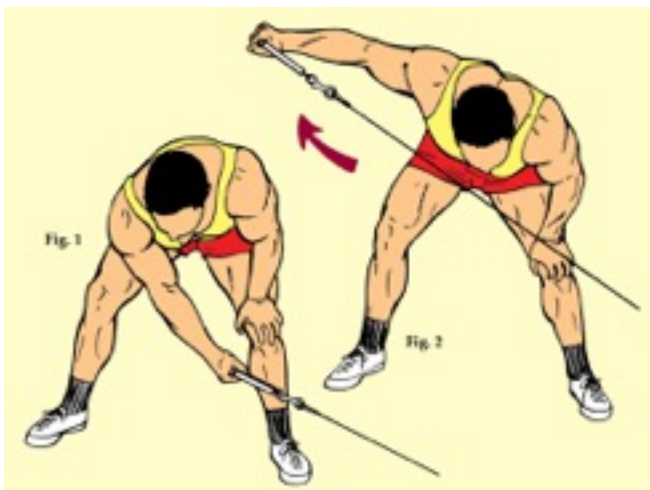
Other movements for the Posterior Deltoids, which depart from that which is described above, would involve varying degrees of "less than ideal".

For example, the exercise below - the standard "Bent Over Real Deltoid Dumbbell Raise" - provides insufficient resistance at the beginning of the range of motion, too much resistance at the end of the range of motion, isn't the ideal anatomical motion, and unnecessarily loads the Lower Back.

Of course, it's more convenient to pick up a pair of dumbbells and do this exercise (above), as compared with setting up a pair of pulleys - assuming one even has access to pulleys. But that does not negate the fact that the exercise above is less efficient, less comfortable, less natural a shoulder movement, and less productive as a Rear Deltoid builder - than the Cross Cable Rear Deltoid exercise shown above.

The *Reverse Butterfly Machine* exercise is more comfortable and provides a better resistance curve than Bent Over Dumbbell Raises, so that might be a good "second best" choice. But the Cross Cable exercise with a more downward angle of humeral movement is truly the best motion, combined with the best resistance curve.

The exercise below - "*One Arm Cable Rear Deltoid Raise"* - has a better resistance curve, because it's more Early Phase Loaded. However, it's still not quite the ideal motion. In terms of Lower Back strain, the exercise below loads the Lower Back much less than the *Bent Over Dumbbell Raise*, for two reasons. Only one arm is being used at a time, and the resistance is not pulling straight down. So this is still a better option that *Bent Over Dumbbell Raises*.



The exercise below - "Incline Rear Dumbbell Raises" - has an anatomical motion that is **worse** than the standard *Reverse Butterfly Machine* or *Bent Over Rear Dumbbell Raises*. The reason for this is that the motion is starting low and ending high. The motion needs to start high (and "in") and end low (and "out"), because that's the pathway that moves through the plane of the muscle insertion, and toward the muscle origin.

Also, the alignment is not correct. The alignment (direction of resistance, relative to the torso) is loading the Lateral Deltoid more than the Posterior Deltoid. You can clearly see this in the smaller photo (showing the conclusion of the movement).

However, the exercise above can be made better, simply by pulling the humerus in a more downward / backward angle, as was demonstrated in the Cable movement. It's a little bit like a Rowing motion, but with straight arms, and arms not quite so close to the torso.

THAT direction of movement would following the origin and insertion of the Posterior Deltoid. The resistance curve would still not be ideal. It would still be "too light" at the beginning, and "too heavy" at the end. But it's probably easier for most people to do, as compared with the Cable exercise. And, this has the added benefit of not loading the Lower Back.

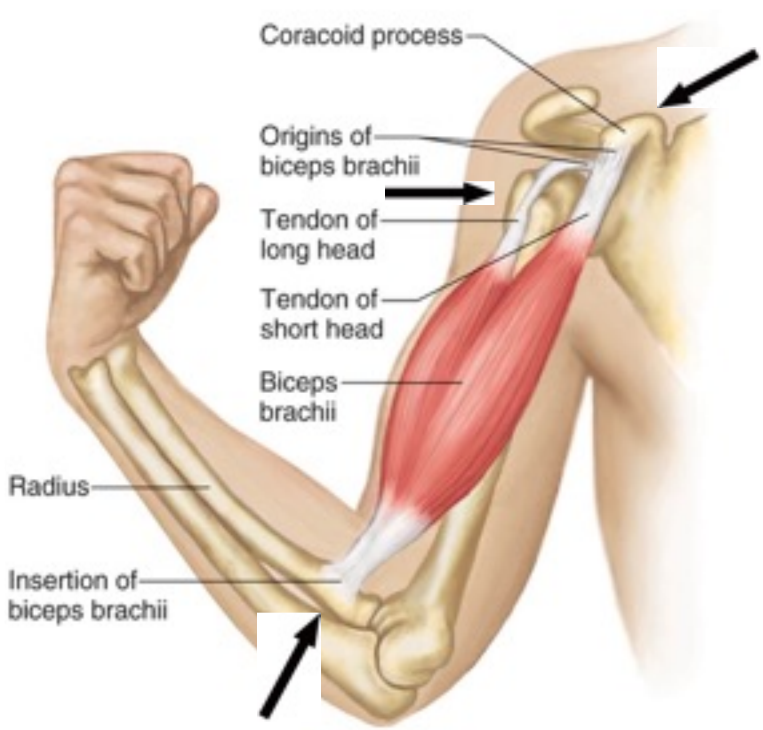
Lastly, the exercise above is a good option - although still quite as good as the Standing Cross Cable Rear Deltoid exercise shown earlier. The direction of resistance is good, of course - in that it provides Early Phase Loading. However, the movement still needs to be more “**downward** / backward” - rather than straight back / perpendicular to the torso. Also, one might lift off the bench if the weight being used on the pulleys is substantial. But it has a decent resistance curve and the Lower Back is not loaded, and these are good features.

Chapter Twenty-One

Biceps, Triceps & Forearms

The **Biceps brachii** is the muscle that most symbolizes “strength”, even though it is not the largest, nor the most powerful muscle of the body. Maybe it’s because of its curious “ball” shape, when it’s well-developed. Many men prioritize “big arms”, often to the neglect of other more functionally important muscles. Nevertheless, a “complete physique” does require well-developed Biceps.

The Biceps' primary function is "elbow flexion" (to bend the elbow). Two other smaller muscles **assist** in that action - the brachioradialis and the brachialis - but neither plays as significant a role in elbow-flexion, as does the Biceps. The Biceps also assists in shoulder flexion (raising the arm forward). However, that's a very minor role for the Biceps, because the Anterior Deltoid is the primary shoulder flexor.



In the illustration above, we can clearly see that Biceps is a muscle that is comprised of two “heads”. More specifically, it is a muscle with two origins. One of the heads is called “the Short Head” and the other is called “the Long Head”. The short head originates on the Coracoid process (of the scapula) and the long head originates on the “Glenoid tubercle” (of the scapula). As you can see above, the long head of the Biceps wraps over the top of the humerus, and sits in a crevice called the “Intertubercular groove”.

What’s more important to note, however, is that both Biceps heads CONVERGE at the one, **singular** Biceps tendon, before crossing the elbow. The singular Biceps tendon crosses the elbow, and connects to the Radius of the forearm.

This is important to note, because when the Biceps bends (“flexes”) the elbow, it is a combined effort of both Biceps heads. The elbow joint can only bend in one direction - like a hinge. Therefore, It is **impossible** to isolate the “long head” (also referred to as the “outer Biceps”) or the “short head” (also referred to as the “inner Biceps”). Both heads contract in unison, if they work at all.

We often hear people suggesting that a particular exercise will “emphasize” the outer head or the inner head, of the Biceps. This is “wishful thinking.” It is NOT accurate. Logic and science clearly show that this impossible.

IF it were possible to emphasize the “Inner Biceps” or the “Outer Biceps”, it would require that the elbow bend in more than one direction, and it would require two separate tendons crossing the elbow, and two separate insertions on the forearm.

For example, in the illustration below-LEFT, I have modified the actual anatomy, so that instead of there being only one Biceps tendon (below-RIGHT), there are TWO tendons, with two separate insertions. Now **imagine** that instead of the elbow bending like a hinge, it is able to bend like a ball and socket (i.e., in more than one direction). If these circumstances were REAL, the “outer Biceps” (shown in red) could pull the forearm more toward the outside, and the elbow would allow that kind of bend. The “inner Biceps (shown in green) could pull the forearm more toward the inside, with the elbow allowing a different angle of bend. Thus, choosing the direction of elbow-movement, we could emphasize either one side of the Biceps or the other. **But this is not reality.**

*(Note: Rotating the arm **at the shoulder**, internally or externally, does **not** constitute bending the elbow in a different direction.)*

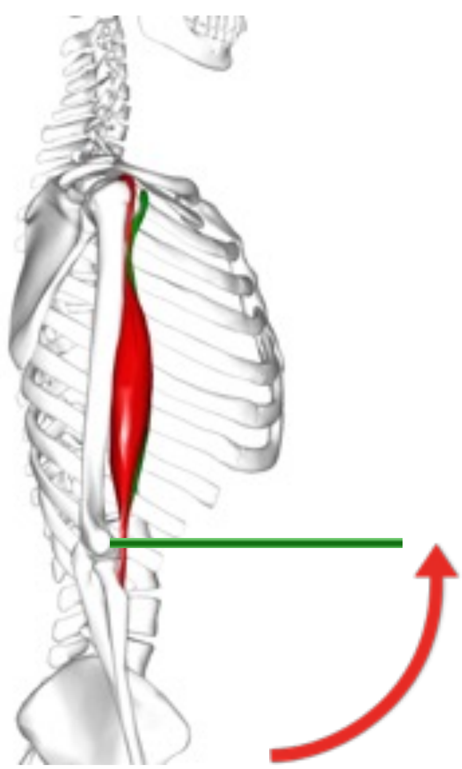
The reality is that both Biceps heads act as one. They both pull simultaneously on the one single Biceps tendon, which produces the one single action of elbow flexion, which can only occur in one single direction.

Regardless of whether one uses a barbell or dumbbells; whether one performs a *Preacher Curl* or a "*concentration curl*"; whether one uses a hammer grip or a palms-up grip; or whether one does curls on an Incline Bench - the Biceps works the same in all circumstances, in terms of its "parts" (long head / short head). **We cannot change the shape of our Biceps** - aside from making them bigger or smaller - by using different exercises.

Of course, some exercises are "better" (more efficient / productive) than others - so they are not all the same in that regard. But they are the same in the sense that doing multiple exercises during a given workout - for the Biceps - is redundant. The same action occurs in the Biceps, from one exercise to the next, but to different degrees of efficiency, productivity and risk.

The Ideal Anatomical Motion of the Biceps

Following our standard guideline for determining "ideal motion", we'll begin with the simplest version of moving the muscle insertion directly toward the muscle origin, without any unnecessary contortion. The purest version of Biceps contraction is simple elbow flexion, **with the humerus at one's side**.



This motion - elbow flexion with the humerus at our side - is the most “natural”. It is the motion / position that is the least contorted, and arguably the one to which we have most adapted. Elbow flexion with any **other** humeral position results in varying degrees of “less natural” - some of which are acceptable, but none of which are actually “better” - in terms of being more productive or more safe.

When this movement / position is done with “free weight” (i.e., dumbbell or barbell), the direction of resistance is straight - a 6:00 direction - parallel with the humerus. This produces a resistance curve that begins with zero, when the forearm is also parallel with gravity, and reaches the 100% active position when the forearm is perpendicular with gravity (green line above). Assuming the humerus has stayed vertical, this would produce a 90 degree bend at the elbow.

This degree of elbow bend, results in a Mechanical Advantage, in regard to the Biceps’ ability to pull perpendicularly on the forearm. This set of biomechanics constitutes perfect synchronization with the resistance curve.

In this scenario, the resistance is the “heaviest” precisely when the Biceps is most “strong” - due to Mechanical Advantage. When the resistance is the “lightest” - at the bottom of the range of motion, when the forearm is parallel with gravity - the Biceps is at its “weakest”, in terms of Mechanical Disadvantage.

At this point, we might ask ourselves, “What about the Biceps strength curve?”. Isn’t the Biceps “strongest” when it’s elongated? Shouldn’t we perform a Biceps curl that begins with a mostly active lever, to accommodate the stronger part of a muscle’s strength curve?

It seems to me that the strength curve of the Biceps is not quite like that of other muscles, like the Deltoids or the Pectorals. This can be easily tested. If you were try to do a Biceps curl on a table top (with a horizontal humerus), you would quickly discover that it has nowhere near the strength in that position, as the Pecs or the Deltoids do. It seems that the strength curve of the Biceps is not much stronger when it’s elongated, as compared with other muscles. Of course, this is also being influenced by the Mechanical Disadvantage.

Also, there is an enormous risk factor when the elbow is straight. As discussed in Chapter 3, the Biceps and Biceps tendon seem to be very susceptible to rupture. When the elbow is straight, and Mechanical Disadvantage is present, the increased force requirement could be as much as six-fold.

Apparently, the Mechanical Disadvantage that is present when the elbow is straight, more than off-sets the decreased level of “activeness” (perpendicular-ness) of the forearm, at the beginning of an upright, free-weight *Biceps Curl*. Even a very slight angle on the humerus and forearm, at the starting position, **greatly** magnifies the difficulty factor. *Preacher Barbell Curls* demonstrate this very clearly.

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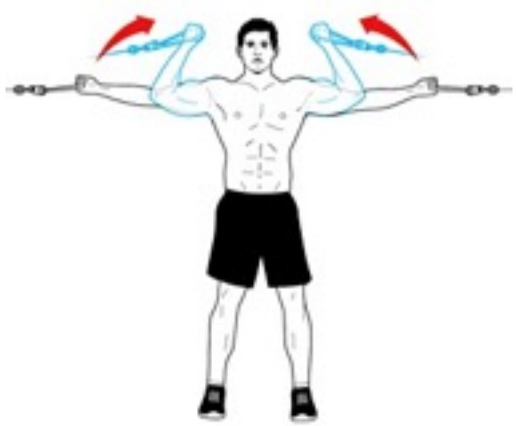
There are numerous Biceps exercises that are commonly performed in a gym. Some begin with our humerus pulled back - as in an Incline Dumbbell Curl. Others begin with the humerus in other positions. However, you'll notice that - regardless of the position of the humerus - the elbow is still doing the same, exact thing, in every exercise.



So, what do these "other" humeral positions change? They may change the degree of stretch the Biceps feels during elongation, or the degree of "shortening" of the Biceps upon contraction. If the humerus is pulled back, it increases the stretch on the Biceps; if the humerus is pulled forward, it shortens the Biceps - and also potentially stretches the Triceps, simultaneously. Are these **changes** productive? Not necessarily.

We learned in Chapter 4 that excessive shortening of a muscle results in weakness, due to the "overlapping actin filaments". We also learned that excessive stretch increases risk, but does not necessarily increase benefit. The "ideal" range of motion is the middle 80%. So, increasing the beginning stretch of the Biceps is not necessarily “better”, and increasing the shortening of the Biceps at the end of the range of motion is also not necessarily “better”. Neither of them will change the shape of the Biceps.

Biceps exercises with the humerus / elbows significantly elevated - which produce a stretch in the Triceps WHILE the Biceps in contracting - may result in “Reciprocal Innervation”. This was discussed in Chapter 11. “Activation” - caused by stretching the Triceps - would result in a “relaxation synapse” being sent to the Biceps, causing it to partially shut down (relax), as you are trying to contract the Biceps. Obviously, this would be counterproductive.

It may not be “bad” to do Biceps exercises with other humeral positions, but there is no real advantage in doing so. Other humeral positions may be as productive, or less productive, and / or more risky - as compared with Biceps exercises that maintain the humerus alongside the torso - but they will not be more productive.

So, if one **enjoys** doing Biceps exercises with a variety of humeral positions, they should do them for the sake of enjoyment - not with the mistaken belief that they’ll provide a different kind of benefit, nor an advantage beyond that which is achieved with the humerus at one’s side.

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Selecting the Ideal Direction of Resistance

The Biceps begins its range of motion with a straight elbow, and then passes through a part of the range of motion where the elbow is at 90 degrees. This means that the Biceps begins its range of motion with an **extreme mechanical DIS-advantage**, pulling the forearm from a mostly parallel angle. Then, the forearm passes through a point in the range of motion, where the Biceps is able to pull on the forearm with a mechanical AD-vantage. This **must** be factored into the decision when selecting the direction of resistance.

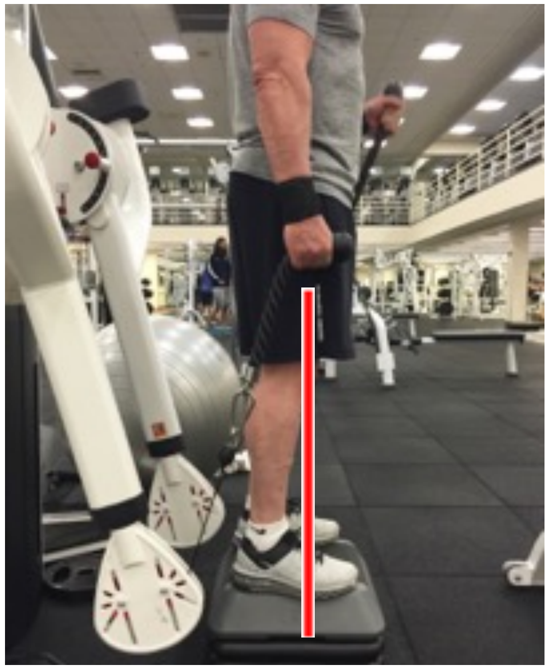
You might recall, in Chapter 3, we discovered that the difference between the amount of force required when pulling on the lever from a perpendicular angle, versus pulling from a parallel angle, was approximately 6X. So, any resistance that the forearm encounters (while being operated by the Biceps) when the elbow is straight, is going to magnified considerably - even if it does not feel that way to the Biceps.

This is why performing a standard, upright (seated or standing) Dumbbell Curl or Barbell Curl, is about as perfect a Resistance Curve as one could ask for.

It may not feel that heavy, at that early part of the range of motion, but that is partly due to the fact that the Biceps is probably a bit **stronger** when it's elongated. It's also due to the fact that most of us give the barbell (or dumbbell) a **nudge** at the beginning, which gives the forearm some pendulum-like momentum (this should be minimized or eliminated, if possible). Generally, we are entirely unaware that we are doing it. But it does lessen the resistance in the early phase, which is not good.

If one wants to increase the resistance a little bit, during the early phase of the Biceps' range of motion, all that's need is to select a direction of resistance that originates from slightly "behind" the humerus / forearm. This can be done by either: 1) changing the direction of resistance (by way of cable), while maintaining the humerus in a vertical position…or 2) continuing to use "free weight gravity", but changing the position of the humerus so that's it's slightly angled.

Below is an example of the first option - changing the direction of resistance (by way of a cable), while keeping the humerus vertical.



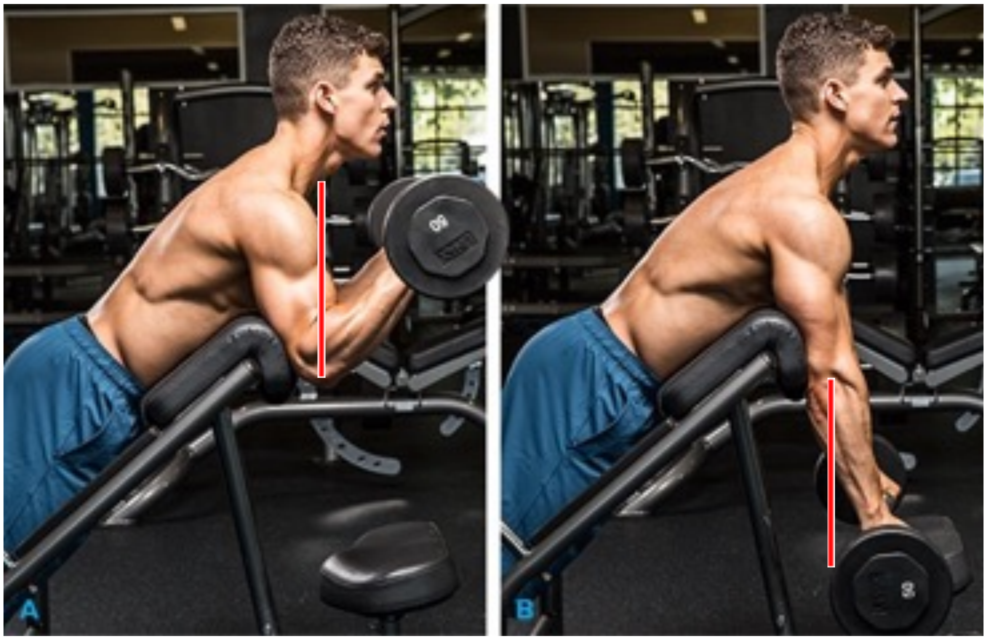
In the photo above, I've place a red line indicating the direction of resistance which would occur with "free weight gravity" - if a dumbbell were held in his hand. That line is almost parallel with Mike's forearm, showing that the starting resistance would be close to "zero", if dumbbells were used.

However, the cable resistance is originating from a source that is slightly "behind" Mike, rather than from "straight down" gravity. THAT line (direction of resistance) - the cable - is slightly more perpendicular with his forearm, than "free weight gravity" would be. That causes the forearm to be more "active" at the beginning of the range of motion, and will therefore load the Biceps a bit more at that stage of the repetition.

If a person wants MORE resistance at the beginning, all that's needed is to step forward a bit. This would cause the direction of resistance (the cable) to originate from a source that is farther back, and would created a more perpendicular angle with the forearm.

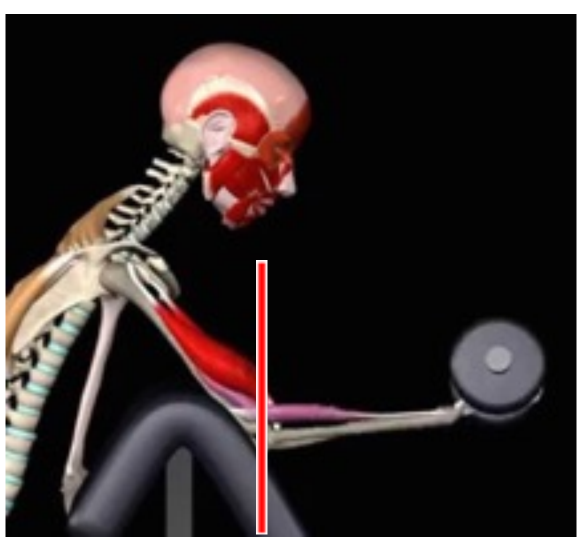
Of course, adding resistance to the early part of the repletion - by changing the direction of resistance - diminishes the resistance toward the conclusion of the repetition. Generally speaking, this is perfectly acceptable. We just don't want the resistance to diminish all the way to "zero", before the end of the muscle's range of motion.

In the photos below, we can see the other option for adding resistance to the early part of the range of motion - assuming one WANTS to do this. In this case, the direction of resistance is the same ("free weight gravity"), but the position of the humerus is angled - rather than vertical.



I’ve placed a red vertical line at the elbow. This shows that the humerus is slightly angled from the vertical position, as would be the case when doing a *Standing* or *Seated Dumbbell Curl*. This humeral position causes the forearm to start the Curl (when the elbow is straight) with some degree of perpendicular-ness. The forearm is now slightly more “active” at the beginning, than it would be if it were vertical - and this causes the Biceps to be more “early phase loaded”.

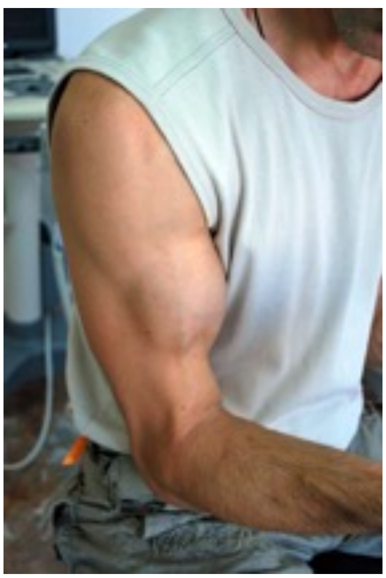
This degree of angle is acceptable. I don’t believe it’s entirely necessary, but it’s a safe option. It will load the Biceps a little more in the early phase, but not so much as to pose a significant injury risk.



The illustration above is showing the angle of a typical “Preacher Curl”. The humerus usually rests on the 45 degree angle pad, which causes the humerus to also be at a 45 degree angle. This is a more severe angle than the example shown before it.

I’ve place the red vertical line through the elbow, showing that - at this position - the forearm is essentially horizontal, which makes it almost fully active. However, the Biceps tendon still has a significant Mechanical Disadvantage. In the early phase of this movement - when the elbow is straight - that Mechanical Disadvantage would be even greater. Yes, the forearm would be less “active”, but that would cause not enough of a reduction to offset the increased force requirement of the Mechanical Disadvantage. This would make the early phase extremely dangerous.

As we discussed in Chapter 3, the vast majority of Biceps ruptures occur when the elbow is straight, or nearly straight - and the Biceps is loaded with a significant resistance. Below are examples of torn Biceps that were not surgically repaired.



The photo above-left shows a Biceps that has had its lower end torn, while the photo above-right shows a Biceps that has had its upper end torn.

I believe it’s advantageous to utilize the “bottom end” of the range of motion, but with a diminished resistance curve. Leaving out the bottom 20% of the range of motion, simply because one wants to do a “safe” Preacher Curl, is not as productive as using an exercise that has a diminishing resistance curve as the Biceps to fully elongates.

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The **best** Biceps exercises, in descending order, are as follows:

1. Seated (or Standing) Dumbbell Curls (simultaneously or alternate)

2. Standing Cable Curls (simultaneously or alternate)

3. Standing Barbell (or EZ Bar) Curls
4. Preacher Cable Curls

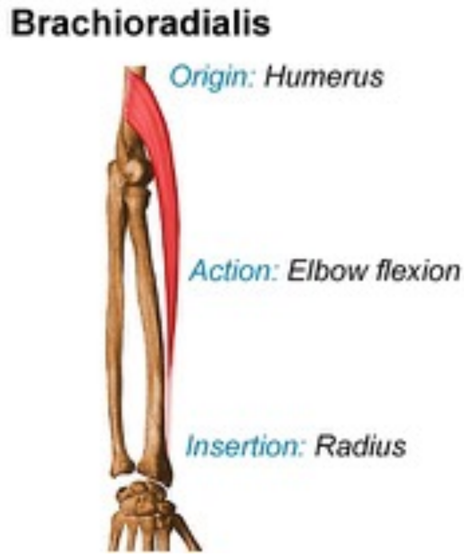
5. Prone (facing down) Incline Curls - with dumbbells or EZ Bar

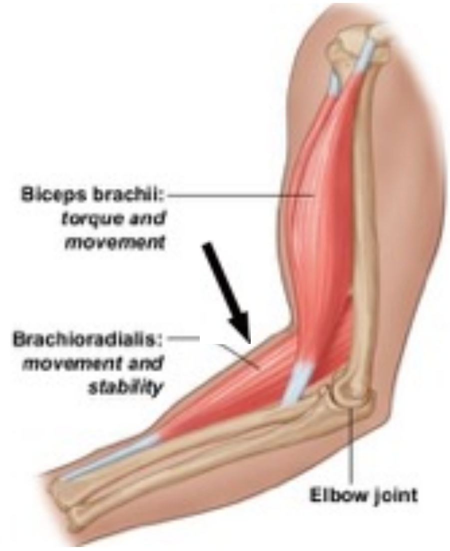
Biceps - Hand / Wrist Position

Some people believe that changing the hand position - using either a “palms up” grip or a “hammer grip” - will somehow work a different part of the Biceps. It will not. The Biceps’ shape will develop precisely as one’s genetics have pre-determined, from birth.

However, the hand position does play a role in the the percentage of force which required of the Biceps and from the **Brachioradialis**.

In the illustrations below, you can see the Brachioradialis appears to be more of a forearm muscle, than an upper arm / Biceps muscle. Of course, it is situated more on the forearm, but its primary job is to assist the Biceps in elbow flexion. It participates more in elbow flexion when we use a “hammer grip” hand position. So, when we use a hammer grip, the Brachioradialis works more and the Biceps less. When we use a “palms-up” grip, we use the Biceps more and the Brachioradialis less.





In my estimation, it seems that when I use a hammer grip (like the one I demonstrate in the photo above), my Biceps does about 70% of the work, and my Brachioradialis about 30% of the work. This is a very rough estimate, of course - based entirely on feeling.

When the hand is **supinated** less (palm turned more upward), the Biceps does a greater percentage of the work, and the Brachioradialis does a smaller percentage. But the Brachioradialis always contributes, at least a small degree, to elbow flexion. It's impossible to eliminate its participation.

One might think that if they **pronated** their hand all the way so that the palm is facing downward (like a "*Reverse Barbell Curl*"), that it would activate the Brachioradialis the most. In fact, this appears to not be true. The Brachioradialis works most when the hand is in the neutral position (hammer grip), and less when the palms are facing downward - studies have shown. Therefore, if you WANT to emphasize development of the Brachioradialis, use a hammer grip on most or all of your Biceps exercises, whenever possible.

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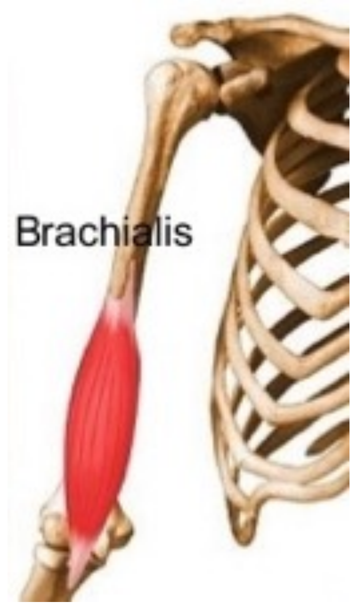
The Biceps also has another assistant during elbow flexion, in addition to the Brachioradialis. It lies **beneath** the Biceps brachii, and it's name is the Brachialis (illustration below).



As you can see, it originates directly on the mid-humerus (just below the Deltoid tuberosity), crosses the elbow joint, and attaches to the forearm, on the “Coronoid process” of the Ulna. Like the two heads of the Biceps, it participates every time the Biceps is activated, and the elbow is flexed - whether we want it to be or not. It cannot be isolated nor emphasized, nor can it be excluded from participating in elbow flexion.

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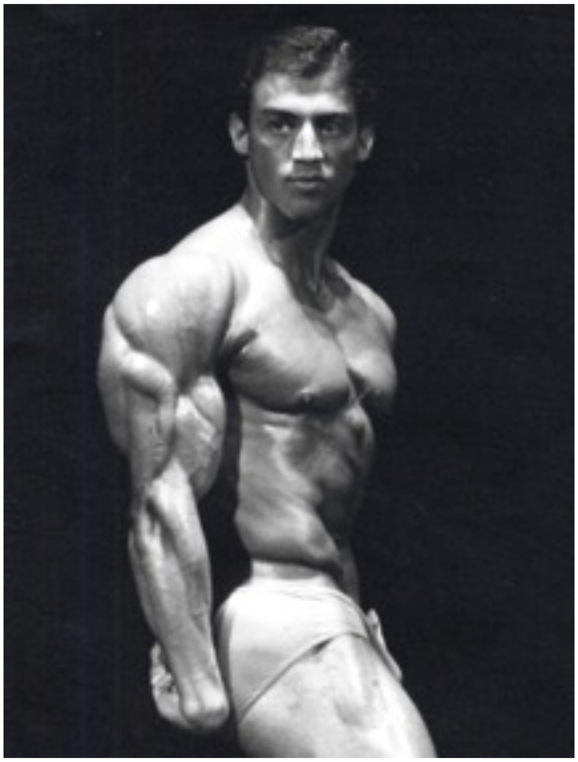
Triceps

The Triceps is the “antagonist” to the Biceps. It is the muscle that operates the elbow in the opposite direction. A nicely developed Triceps lends aesthetic balance to the arm, when both Biceps and Triceps are equally developed. When viewed from the side, a lean and well-developed Triceps has a classic “horse shoe” shape, when flexed.

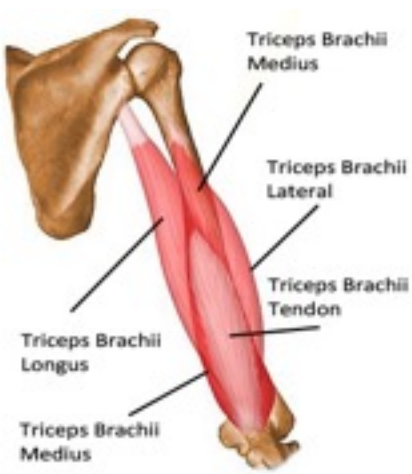
The function of the Triceps is to EXTEND the elbow. This means “increasing the angle” of the joint - moving the elbow from the bent position, to the straight arm position.

It is made up of three “heads”. However - like the Biceps - all three heads operate in unison, whenever the Triceps is activated. The entire Triceps - all three parts - perform the **singular** function of extending the elbow*. As we know, because the elbow is like a hinge, it can only extend in one direction.

(Note: One of the three heads - "the long head" - also assists in shoulder flexion / pulling the arm downward.)



In the illustrations below, we can see the three Triceps heads, and their origins. This is a posterior view (seen from the back) of a right arm. The "Lateral head" (aka "outer head") and the "Medial head" (aka "inner head") **originate** on the back of the humerus. The Long head ("longus") originates on the scapula - just inside the shoulder (Glenoid) socket.



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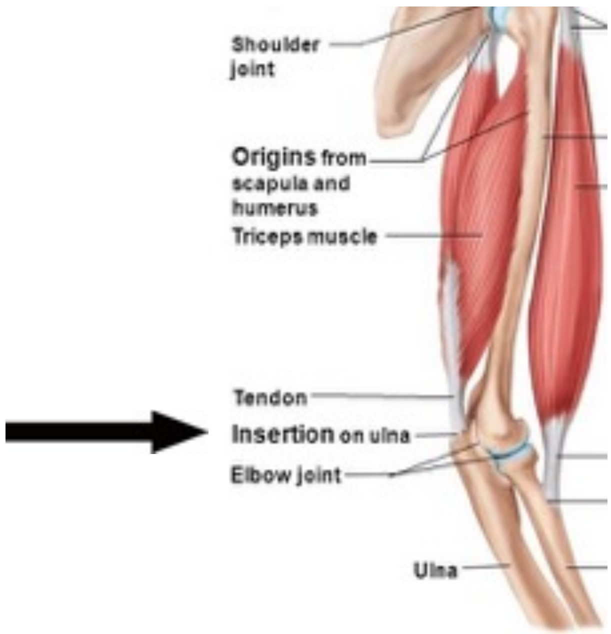
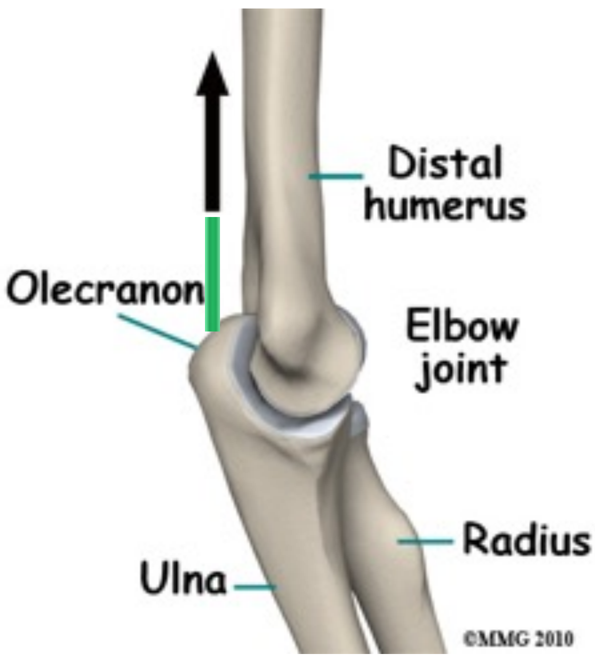
The illustration below is a sideview of the Triceps (of the right arm). Here we can clearly see the **insertion** of the Triceps tendon on the Olecronon process of the Ulna (one of the two forearm bones). Like the Biceps tendon, the Triceps tendon is also **singular**. All three Triceps heads converge and become one, before crossing the elbow.

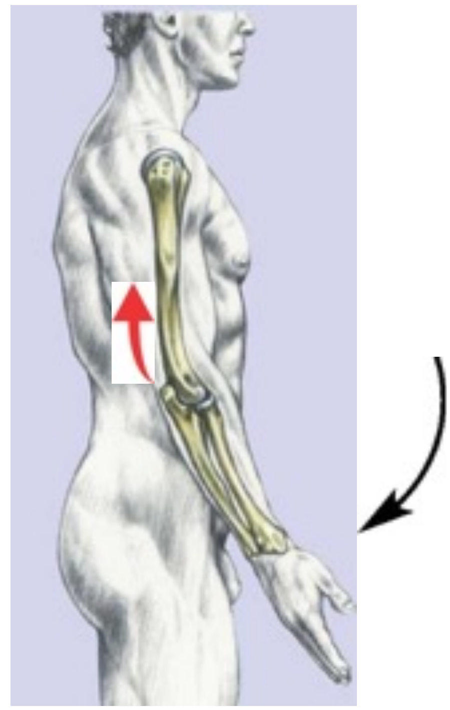


The illustration below-left shows only the arm bones, for the sake of clarity. I've placed a green line coming from the Olecranon process (insertion point of the Triceps), with the black upward pointing arrow. This shows how the Triceps tendon pulls upward on the Olecranon process, thereby extending the elbow.

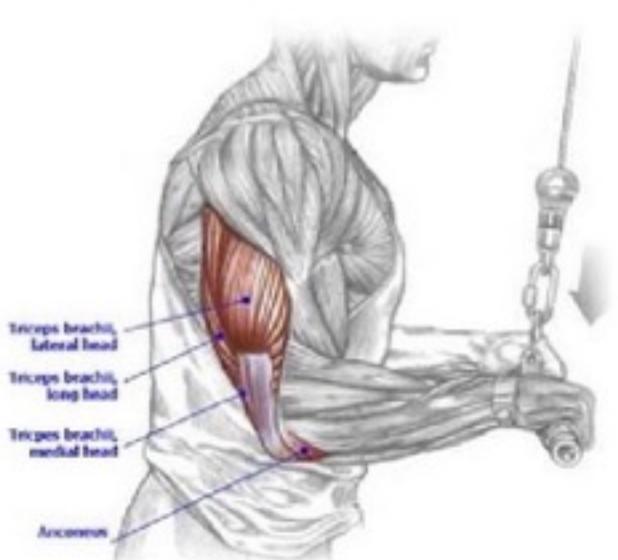
In the illustration below-right, I've place an "up" arrow, showing this same process, but from a wider angle view.

These two illustrations show the **simplicity** of the "Triceps contraction / elbow extension" mechanism. Regardless of the Triceps exercise one chooses to do, this mechanism occurs in every single exercise.





Below is an illustration of a standard Triceps Cable Pushdown, demonstrating the mechanism we see above, during active exercise.



Just like with the Biceps, many people believe that different Triceps exercises - even various hand positions - will somehow emphasize one part of the Triceps, or another. This is simply not possible. Since the elbow only "extends" one way, and since there is only ONE Triceps tendon, there is only one way a Triceps can contract. And when it contracts, all parts of it do so simultaneously. We cannot emphasize the contraction of one part of the Triceps, over another.

People in a gym sometimes do a "*Triceps Pushdown **with palms up***", and then a "*Triceps Pushdown **with palms down***", and then an "*Overhead Dumbbell Triceps Extension*", and then a "*Supine Dumbbell Triceps Extension*" - believing that each of these exercises is contributing a different kind of benefit to the Triceps. This is false. These exercises all work the Triceps the same way, but with different degrees of efficiency, productivity and risk.

Using the example from Chapter 17, if you were a man with a rope, acting as the Triceps muscle, with no way of seeing outside the skin, you would have no way of knowing what exercise is being done. All you would know, is that you are pulling on that Olecranon (insertion on the forearm), thereby causing the elbow to extend. You could not possibly know which way the palm of the hand is facing - nor the position of the body, humerus or shoulder.

You would feel the resistance curve, the amount of stretch, the amount of contraction, the range of motion, the amount of load and fatigue - and that's all. None of these characteristics alter the shape of a muscle, and each of these have a "good", "better" and "best" version.

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The Ideal Anatomical Movement for Triceps

The most normal, natural position for the human shoulder is with arm at one's side - or close to one's side.

Since this is the position most accommodated by evolution, it's logical to assume that it is the strongest position, as well as the safest position, from which to work the Triceps. Therefore, any Triceps exercise that **can** be done with the upper arm at one's side, or close to being at one's side, is likely to be the "ideal" anatomical movement for the Triceps.

Of course, this does not suggest that a person is unable to perform Triceps exercises with other humeral positions, nor that those other positions would be entirely unproductive or unsafe. However, it does suggest that those other positions are **not necessary** for optimal Triceps development, not more productive, and are sometimes less safe.

I realize this flies in the face of conventional wisdom, but let us first acknowledge that there has never been any scientific test that has demonstrated otherwise. Also, from a logical perspective, any position other than the “arms at one’s side” position, does not change the Triceps / elbow mechanics in any way that could be construed as “better”.

The Triceps tendon does only one thing - it pulls on the Olecranon process. Since it’s impossible to change the shape of the Triceps by way of doing different Triceps exercises, the most logical strategy would be to do the Triceps exercise that is most “natural”, least contorted and most comfortable on the shoulder joint.

Certainly, there are those who believe that the “Long head” of the Triceps can be emphasized by performing **overhead** Triceps extensions, of various sorts. However, this relies on the unsupported theory that an exercise which provides pre-stretch builds a muscle better than an exercise that does not. There is no evidence of that, and there is an abundance of evidence that pre-stretch is not necessary nor more beneficial.

As mentioned in a previous chapter, we know that pre-stretching the Quadriceps during a Leg Extension exercise does not increase the increase the effectiveness of the exercise (for muscle growth). We also know that pre-stretching (deep stretching) the Pectorals, during Supine Dumbbell Press, does not build the Pectorals better. Pre-stretch generally increases joint stress, especially when using a heavy weight. In Chapter 10 (“Dyanic” versus “Static” Muscle Contraction), we discussed how it’s usually better to avoid the extreme stretch and the extreme contraction of most ranges of motion, for the sake of safety. “Pre-stretch” and “maximum contraction” have never been shown to be more productive than the middle part of the range of motion.

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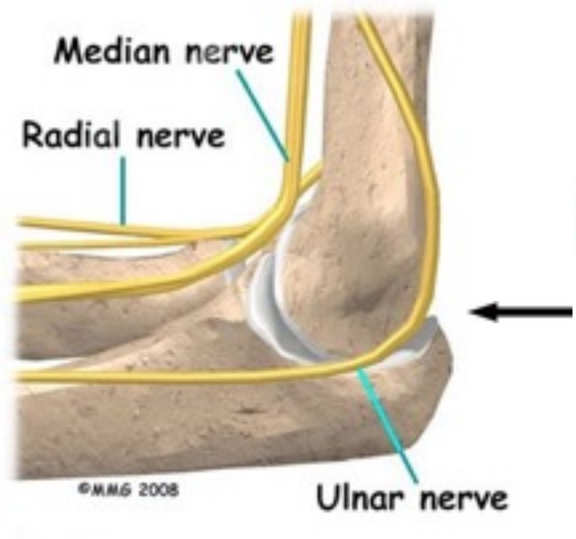
I had been experiencing elbow discomfort when doing Overhead Triceps exercises, a number of years ago. Being the analytical person I tend to be, I started testing various humeral positions. I noticed that there was an increasing continuum of elbow discomfort, from the downward position to the overhead position, when doing various Triceps exercises.

In other words, I had essentially NO elbow discomfort when I extended my elbows while my upper arms were alongside my torso. I had a bit more elbow discomfort when I extended by elbows with my upper arms forward / perpendicular to my torso. And I had the most elbow discomfort when I extended my elbow while my upper arms were alongside my head, doing “overhead” Triceps exercises.

Of course, this makes sense from an evolutionary perspective. While it’s likely that our early ancestors extended their elbows from a variety of angles, they probably extended their elbows least often with their upper arms overhead.

What might cause an elbow to feel pain **when the arms are raised**? The Ulnar nerve.



The Ulnar nerve usually passes through a space (groove) between the humerus and the Ulna. However, it's obvious that placing one's arms overhead can cause the nerve to be more taught. So, if doing Overhead Triceps Extensions could cause nerve pain in the elbow, and it does not improve the Triceps / elbow mechanics - why bother with it? Overhead Triceps exercises are also less comfortable (and more risky) on the shoulder joint.

Following this logic, I decided to do ONLY **downward pushing** Triceps exercises (humerus alongside my torso), to see what would happen. I mostly did *"Extreme Decline Dumbbell Triceps Extensions",* and occasionally did a modified *Triceps Pushdowns* (which I'll describe below). I was confident that this would minimize elbow discomfort, and provide ALL the hypertrophy benefits, without compromise. I did this for a two-year period of time, after which I competed in the World Championship of bodybuilding (WFF). My Triceps were as well-developed as ever. In other words, my belief proved to be correct.

It's simply not **necessary** to do any Triceps exercise where the upper arm is positioned other than close to the torso. There is no advantage in doing Triceps exercises with other humeral positions. In fact, I believe other exercises are less productive, less comfortable (on the elbow and shoulder) and less safe.

Consider the fact that when we flex our Triceps (to savor a "pump" during a workout, or to check for soreness from a previous workout), we **always** flex our Triceps with our humerus down - alongside our torso, or close to it. We never flex our Triceps with our humerus "up" alongside our head. The lower we hold our humerus, the better we can flex our Triceps. That seems to be the position which best allows us to engage our Triceps.

It may be “fun” to do a variety of Triceps exercises with other humeral positions. It may also be more practical, based on the availability of what equipment. But there is no logical reason to believe it’s more productive, or more safe. In fact, there are reasons to believe it is **less** productive and **less** safe - at least to some degree.

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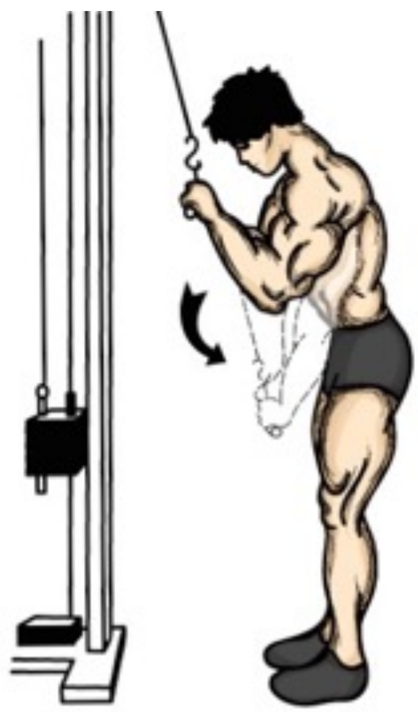
Choosing the Ideal Direction of Resistance

The general rule is to select a direction of resistance that provides “early phase loading”, alignment and “opposite position loading”.

Let’s look at a traditional Triceps exercise, and see if it provides the “ideal” direction of resistance - or if we can improve on it to some degree.

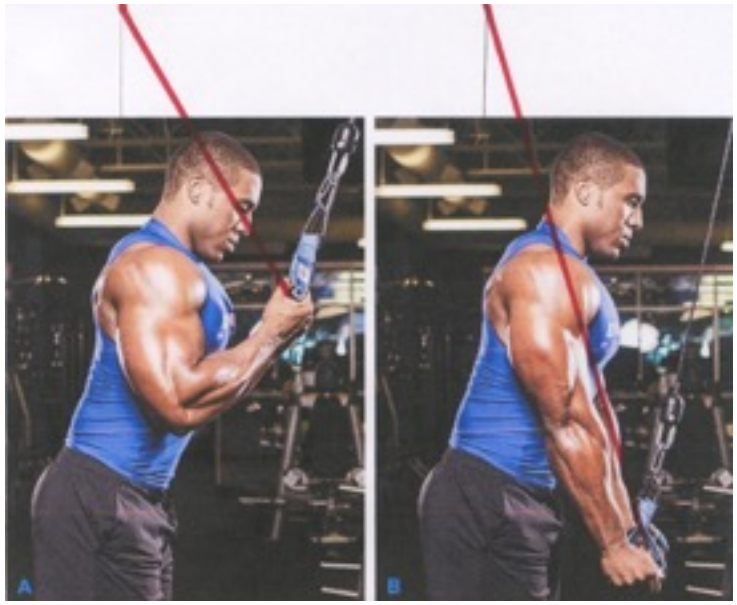
In the photo below-left, and the illustration below-right, we see the starting position of a *Triceps Cable Pushdown*. Notice that the cable (which indicates the direction of resistance) is **parallel** with the forearm, in both examples (a bit more so on the left, than on the right). This makes the forearm NEUTRAL - which provides zero resistance to the Triceps. However, this is the “early phase” of the range of motion of the Triceps. This is where the lever **should** either <u>most active</u> (perpendicular), or mostly active (nearly perpendicular) - yet it’s not. It’s also worth noting that the humerus (upper arm bone) IS mostly perpendicular with cable, but it’s being controlled by the Lats, in this scenario. So, in this starting position, the Lats are more loaded than the Triceps. This is not good.



Now, in these photos below, we see the starting position **<u>and</u>** the ending position. In the starting position, the forearm is nearly parallel with the cable (photo below-left). In the ending position (photo below-right), it is more perpendicular than it was in the beginning. The forearm would reach the “most active” position about three quarters of the way through the range of motion. This makes the standard *Triceps Pushdown* more “late phase loaded”, than “early phase loaded”. And the Lats are engaged throughout the entire time - unnecessarily - because the **humerus** is fairly perpendicular with the cable throughout the entire exercise.

What’s needed here is a different direction of resistance - one that is MORE perpendicular with the forearm at the beginning of the range of motion, and LESS perpendicular with the forearm at the end of the range of motion. Obviously, this “new” direction of resistance would have to originate from slightly BEHIND him - rather than in front of him, as it is now.

Below, I’ve drawn a RED line over the same photos - indicating the “better” direction of resistance. In addition to providing a better resistance curve for the Triceps (“early phase loading” and a diminishing resistance in the “late phase”), it also UN-loads the Lats. It does this because the angle between the cable and the humerus is a less perpendicular angle now.



Of course, this angle of resistance would be difficult to set-up on a standard Cable / Pulley normally used for Triceps Pushdowns. The single cable would have to be either on one side of the head or the other - which would be awkward and asymmetrical.

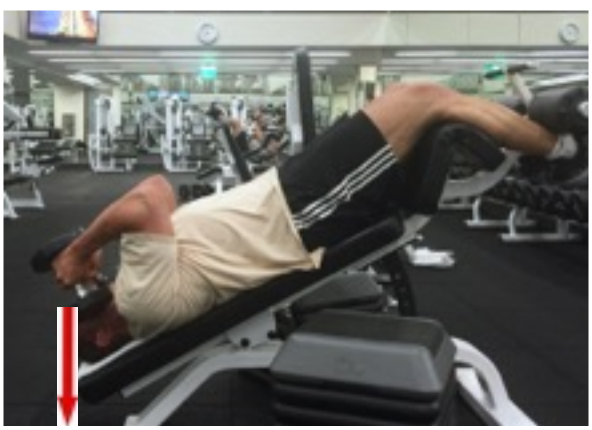
The solution is to use **two** pulleys - positioned correctly - shoulder width apart. Or, one could just do one arm at a time.

Now, we have the humerus close to one's sides - as is typical of a standard Triceps Pushdown - but with a better resistance curve. The Triceps will encounter more resistance at the beginning - where it's stronger, and less resistance at the end - where it's weakest. Even the alignment is better (see blue lines below).

This exercise can also be done while seated. It requires a bit more set-up (bringing a bench), but it's much more stable, and allows better focus on the Triceps.

The exercise below - “Supine Dumbbell Triceps Extensions” - is another common Triceps exercise. It has an excellent “early phase loaded” resistance curve. However, the humerus farther away from the “natural” position than I think is ideal. If you tried to achieve that maximum Triceps contraction, which we’re able to feel during a Triceps Pushdown (when the humerus is closer to one’s side), you’d find it elusive.

The solution is to use a bench that has a very “decline” angle to it, like below. Now, the humerus is approaching the position of a “Pushdown”, but while using free weights instead of a cable.



Here again, you can see that the starting position (above-left) provides a more perpendicular angle between gravity and the forearm, and less with the humerus. This provides more resistance to the Triceps and essentially zero to the Lats. The ending position diminishes the resistance to the Triceps as it enters its weak portion of the range of motion. Again, this exercise represents the best anatomical motion combined with the ideal direction of resistance.

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Here are the top five Triceps exercises, based on ideal anatomical motion and ideal direction of resistance.

1. Extreme Decline Dumbbell Triceps Extensions (slow and deliberate)

2. Modified Cable Triceps Pushdowns (as shown above)

3. Slightly Decline Dumbbell Triceps Extensions

4. Flat / Supine Dumbbell Triceps Extensions

5. Standard Cable Pushdowns

While we're at it, below are the WORST Triceps exercises, due to compromised direction of resistance and/or compromised anatomical motion:

1. Bench Dips (very unnatural humeral movement, strains and over-stretches Anterior Deltoid, forearm is almost entirely "neutral" / parallel with gravity)

2. Parallel Bar Dips (similar problems as the one above)

3. Triceps Kickbacks (Late Phase Loaded, zero resistance at most important part of the range of motion, incomplete range of motion)

4. Anything overhead (unnecessary shoulder and elbow risk, impossible to contract Triceps in this position, no proven benefit to Long head stretch)

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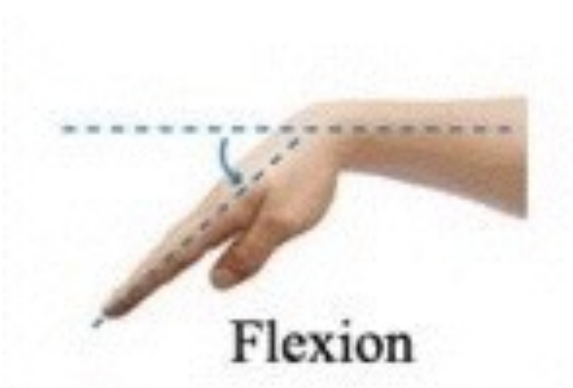
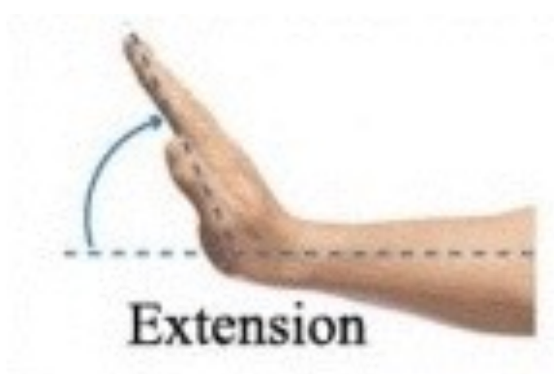
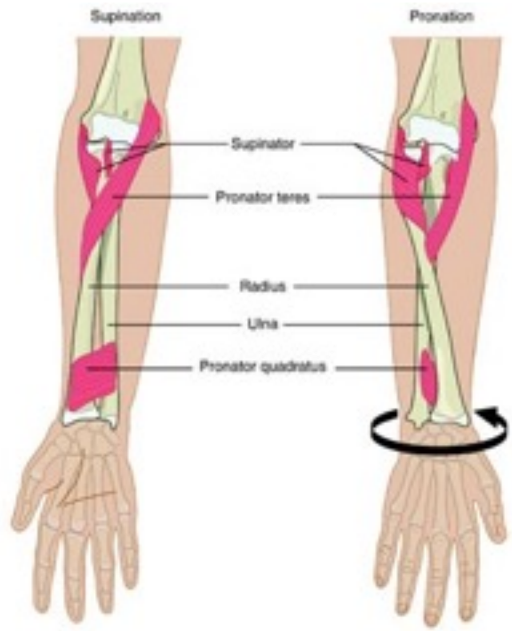
Forearms

Basically, the forearm muscles can be divided into four parts. The “flexors”, the “extensors”, the “rotators”, and the Brachioradialis - which we already discussed in the Biceps section. The “flexors” are the muscles on the side of the palm of the hand (they flex the wrist), and the “extensors” are the muscles on the other side (they extend the wrist). The “rotators” supinate (rotating externally) and pronate (rotate internally) the hand.







The anatomy of the forearm muscles is very complicated, with layers of muscles crossing in many directions. Yet, **the mechanics of wrist movement is very straightforward**. The wrist is not quite like a hinge; it bends forward and backward (flexing and extending) - but it's also capable of circular motion. The primary musculature of the forearm, however, simply flexes and extends the wrist.

The primary forearm exercises, for the purpose of physique development are standard "wrist curls" and "reverse wrist curls" (below).

The exercise is below is the standard "*Barbell Wrist Curls*", which works the "flexor" muscles on the side of the palm of the hand.

The exercise below is one version of the “Reverse Barbell Wrist Curls”, which works the “extensor” muscles on the side of the back of the hand.

Both of these exercises have some degree of inherent mechanical difficulty. In the first two photos (*Barbell Wrist Curls*), one must keep the two forearms parallel to each other, otherwise the wrists will not bend on the same axis. For this reason, it may be easier to do the exercise with a pair of dumbbells - where two separate wrist axises can be used. This would allow each wrist to move the way it “wants” to move, without being forced (by the barbell) to bend on the same axis as the other wrist.

In the second set of photos (*Revers Barbell Wrist Curls*), you’ll notice that I’m using an EZ Curl Bar. If you experiment with this movement, you’ll quickly notice that the hands “extend” upward with the knuckle of the pointer finger, **higher** than the knuckle of the “pinkie” (the little finger). This makes using a straight bar difficult. Using an EZ Curl Bar (with the hand positioned properly on the bar), allows the hand to assume that natural position - leading with the pointer knuckle - without strain.

On the *Reverse Wrist Curl*, there is also the problem of grip strength. The strength of the fingers is not, and will never be, as great as that of the forearm extensors. Thus, the fingers will always fatigue first - assuming one is using a weight that is challenging enough for the forearm extensors. For this reason, you see me using straps here. Wrapping the strap around the bar minimizes the reliance on the grip. This allows me to focus on the forearm extensors, without a “weak link in the chain” preventing me from exhausting the forearm muscles.

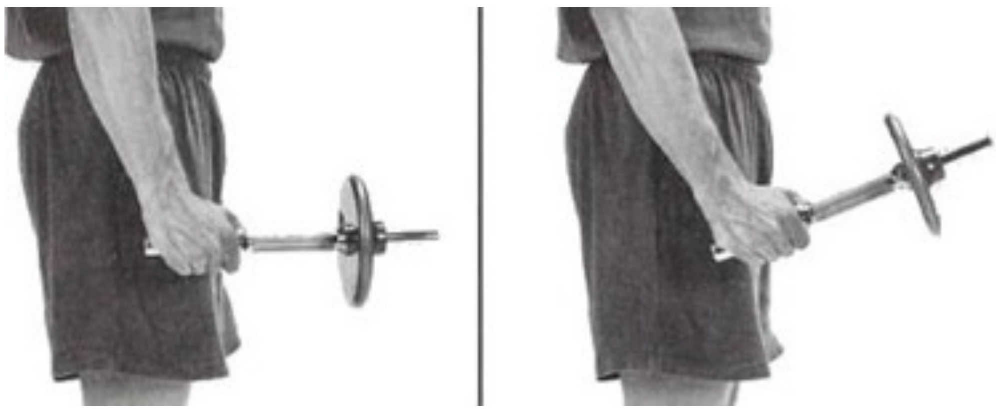
This movement can also be done using dumbbells (simultaneously or separately), and would likely be better for the same reason as the first exercise. It allows independent wrist movement, eliminating the possible wrist discomfort caused by using a barbell. The straps would still be helpful when using dumbbells.

Below are some of the other exercises we often see people using, in their effort to develop their forearm muscles. None of the ones shown below are “as good”, as the ones above - in my opinion.

1. “Behind the Back Barbell Wrist Curls”

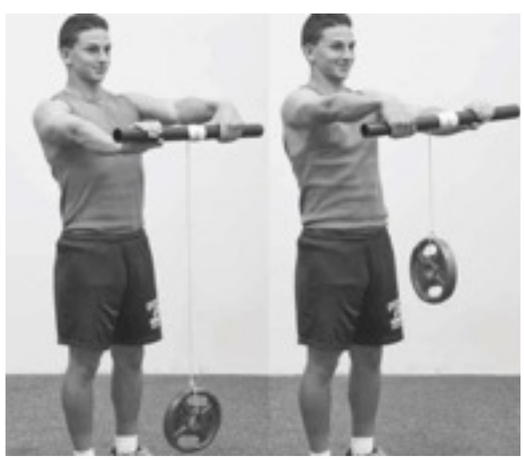
There are two major problems with this movement. The first is that it only works HALF the range of motion. In Chapter 6 (“The Apex and the Base”), we talked about exercises like this, where the Apex or (in this case) the Base, occurs somewhere in the middle of the range of motion. The stretch part of this movement is eliminated, and that is arguably the more important part of the range of motion (the Early Phase). Also, this movement increases the resistance as the muscle contracts, and reduces it as the muscle (partially) elongates. So, the resistance curve also is not ideal.

2. This motion (below) is known as “**Radial Deviation**” (sideways wrist movement - pulling upward / toward the thumb). It might be helpful for specific physical therapy, or it may be helpful for a particular type of job or sport. However, for practical (day to day) purposes, most of us never experience a situation that causes us to think that we are “weak” in this particular movement. Further, there is very little to be gained - in terms of visible muscle growth - from this type of motion. The muscles that produce this movement (“***Extensor carpi radialis longus***" and “***Extensor carpi radialis brevis***”) are very small, and do not have much capacity for growth. Lastly, the wrist mobility in this direction is very limited, and could result in pain or discomfort.



*(Note: Wrist motion in the opposite direction is called “**Ulnar Deviation**” - pulling the wrist laterally downward - toward the small / pinkie finger. This would have to be done with the weight on the posterior side, rather than on the anterior side. This movement is produced by the “**Flexor carpi ulnaris**” muscle - also a very small muscle without much capacity for growth.)*

3. The exercise shown below is called the “Wrist Roller”. It’s an old classic exercise where a weight is pulled up by way of a roped being wound up onto a handle.



This exercise feels like it would be effective, because it produces quite a “burn” in the forearms. However, it ends up being much less effective than standard *Barbell Wrist Curls* and *Reverse Wrist Curls*, in terms of visible forearm muscle growth.

We sometimes see people doing exercises that involve finger resistance, by way of springs, elastic bands or squeezing a rubber ball. These might be useful in some cases involving physical therapy or rehabilitation, but they are generally not very useful for day to day purposes. They generally do not produce a visible increase the size of the forearm flexors or extensors.

Lately, I’ve been seeing rubber grips (like the ones below) - meant to be put on barbells and dumbbells. The idea here is that - since they are considerably larger (thicker) than a standard barbell - grip strength is more challenged. Obviously, they are meant more for pulling barbells, than for pushing barbells.

Of course, any type of physical challenge prompts an adaptation, and this is no exception. However, the **gripping** muscles of the hand and forearm are tiny, and don’t have much capacity for growth.

Also, most of us rarely find ourselves in a situation where we don’t have **enough** grip strength - especially if we already lift weights three to six days per week. So, this seems like a solution looking for a problem. Generally, we have enough grip strength - and grip strength can only be increased marginally anyway.

This type of challenge would compromise one’s ability to do pulling exercises as effectively, for the intended target muscle. The hand and forearm fatigue would likely fatigue first, before the target muscle we are intending to work is exhausted.

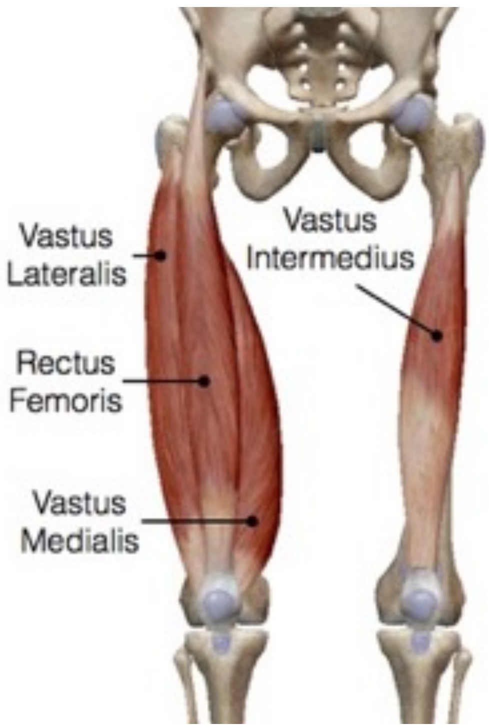
Chapter Twenty-Two

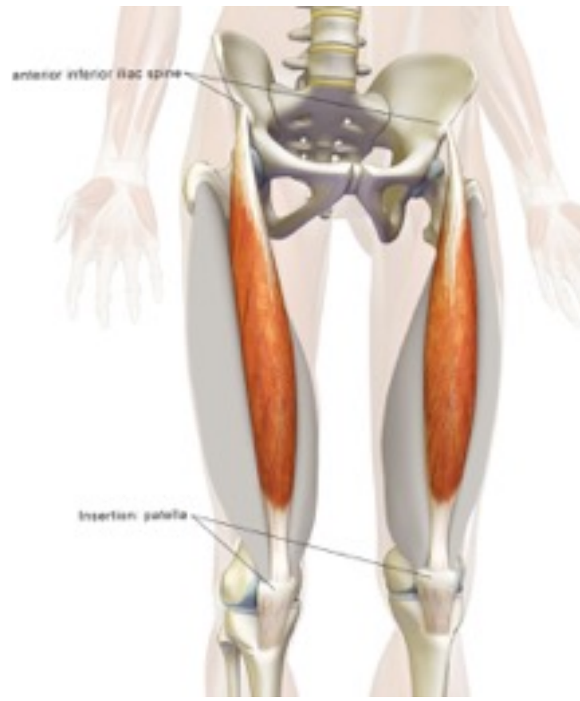
Quadriceps & Hamstrings

The legs are comprised of many individual muscles, but from the perspective of "physique development" we need only concern ourselves with four groups - the Quadriceps, Hamstrings, Glutes and Calves. This chapter deals with the first two.

The Quadriceps (also known as "Quads") is a four-part thigh muscle that stretches from the top / front of the femurs & pelvis down to the knee. As with most of the other physique muscles, there have been a number of misconceptions regarding the best way to develop this muscle. But it's much simpler than most people imagine.

In the illustration below-LEFT, we see the four Quadriceps “heads”. The **Vastus Intermedius** lies beneath the other three muscles - so it is not visible, even when one is totally lean. The visible “heads” are the **Vastus Lateralis** (the outer portion of the Quadriceps), the **Rectus Femoris** (the middle muscle), and the **Vastus Medialis** (the inner portion, also referred to as the “tear drop” muscle).

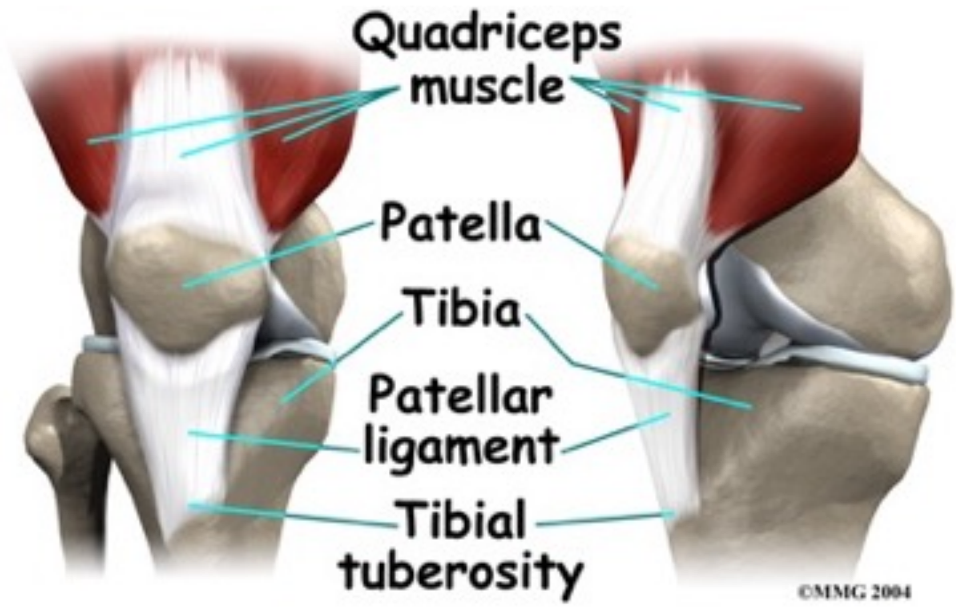




Notice that **three** of the four “heads” originate directly on the upper end of the femur (the thigh bone), but one part (the Rectus Femoris) originates on the pelvis - above the hip joint. That is why this particular muscle is capable of assisting - to a small degree - in flexing the hip joint. It is not a powerful hip flexor, because it’s origin is barely above the hip joint, as compared to the other “hip flexors” (Iliopsoas, etc.). But it does play a minor role in that function.

The illustration above-RIGHT gives a better view of the Rectus Femoris’ alone, and we can more clearly see the origin on the pelvis. It then extends down to the Quadriceps tendon (just above the knee), where all four parts of the Quadriceps converge.

So, although the Quadriceps has four heads, it only has one single tendon at its insertion, which extends the hinge-like knee in only one single direction. All four parts of the Quadriceps work in unison to produce that one primary action, regardless of whether we’re doing *Squats*, *Leg Press*, *Leg Extensions* or any other activity that requires knee extension.



The illustration above allows us to see more clearly how the Quadriceps tendon (above the knee) becomes the Patellar ligament (below the knee), and attaches to the Tibial tuberosity on the front of the Tibia.

When the Quadriceps contracts, it produces an upward pulling on the Quadriceps tendon and the Patellar ligament, which straightens the knee. Thus, it is absolutely impossible to somehow CAUSE the outer part of the Quadriceps (as an example) to contract more than the inner part, given that the Quadriceps tendon / Patellar ligament only pull in one direction, and the knee only extends one way.

There could be a difference in the “resistance curve”, from one exercise to another. This refers to where (in the range of motion) the Quadriceps encounters more or less resistance. But this would not effect the shape of the muscle. It would only affect the **efficiency / productivity** of the exercise.

The “ideal” anatomical <u>**motion**</u> for the Quadriceps is a simple knee extension - whether it is in the form of an isolated exercise, or combined with hip extension (i.e., a compound exercise). Either way, the Quadriceps works the same.

Let’s look at the some of the most common exercises typically used for Quadriceps development, and identify what’s good about them and what’s not so good about them.

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Leg Extensions

The “*Leg Extension*” is the most direct and isolated of Quadriceps exercises. Most modern manufacturers typically use a cam to create a “resistance curve” that they believe matches the strength curve of the muscle, or will appeal to the majority of users. The one shown above (circa 1984) has a half circle (semi-hidden behind my feet and ankles) which swings the cable outward a bit more than it would, if the cable connected directly to the machine’s lever arm. Frankly, I loved this particular machine. Today’s machines typically provide a resistance curve that does not diminish the resistance enough toward the end of the range of motion.

In any case, this is a great exercise - generally speaking. Assuming one’s knees are un-injured, it’s a perfectly safe and very effective way of loading the Quadriceps. Of course, this assumes the machine is well-designed - that pivot in the correct place, and the cam is providing the proper resistance curve. Needless to say, the exercise **isolates** the Quadriceps. No other leg muscle is involved, as would be the case during an exercise that also requires hip extension.

As I mentioned earlier in this chapter, any exercise that requires knee extension against resistance, loads the entire Quadriceps in unison. So, doing multiple Quadriceps exercise in the same workout - for example, *Leg Extensions* AND *Squats*, would be redundant. So, I separate these in alternating workouts.

During one leg workout, I’ll do Cable Squats, Leg Curls and Calves. And on the following leg workout, I’ll do Leg Extensions and Glute Extensions (thereby hitting the two primary muscles worked during Cable Squats), plus Leg Curls and Calves.

Both exercises (Leg Extensions and Cable Squats) are good. They each have their merits, which is why I like doing them both - just not in the same workout.

I would advise that *Leg Extensions* **not** be fully locked out (straight leg / full contraction), however. The reason for this is that the Tibia and the Femur have different shaped "condyles" - the tendinous linings that cover the ends of the bones. During the final part of the range of motion (10 to 20 degrees, depending on the reference) of a Leg Extension, there is a rotation of the two bones - sometimes referred to as "screw home" rotation. As the knees conclude the final part of their extension, the two bones (Tibia and Femur) rotate, so as to accommodate the closing of the space. The Tibia and Femur (actually, the opposing condyles) will only "seat together" when this shifting occurs.

It's logical to assume that if we repeatedly cause "screw home rotation" of these two bones - by always **fully** extending on *Leg Extensions* - that the condyles would eventually be eroded or otherwise damaged. Plus, it's not necessary to fully straighten the knees. As discussed earlier in other chapters, the early part of the range of motion is the most the most productive. It has the greatest strength potential.

In the photo above, I was only 24 years old - and not yet aware of this concept ("screw home" rotation of the Tibia and Femur, upon full extension). For the last 10 years, I've been using the middle 70 to 80% range of motion with Leg Extensions. This seems to provide all the benefits without knee irritation.

On a separate note, there are some people who believe that *Leg Extensions* are bad for the knees, because they produce a **"shearing effect"** - which displaces the Tibia from the Femur. **This is not accurate**. For a full explanation of why it's not accurate, see the article I wrote on this topic (link below). In fact, the theory itself is completely illogical, in light of basic physics facts.

http://www.labrada.com/blog/workouts/is-the-open-chain-closed-chain-exercise-philosophy-shear-non-sense/

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Analysis of the Squat

The *Barbell Squat* is considered by many as the "primary" exercise for Quadriceps development. In fact, combining various **types** of Squat or Leg Press, along with Leg *Extensions*, is a bodybuilder typical Leg (Quadriceps) Workout.

In Chapter 2 ("Active Levers & Neutral Levers") we established that a lever (like the Tibia / lower leg, in this case) is always the LEAST loaded when it is parallel with resistance, and it is the MOST loaded when it's perpendicular with resistance.

Since the **Tibia** is the operating lever of the Quadriceps, we must ask ourselves the question, “How perpendicular with resistance is the Tibia, during *Barbell Squats*?”. The answer to that question will determine how **efficient** the exercise is. If your Tibia is mostly parallel with resistance, the exercise is very **<u>in</u>**-efficient (but the weight will feel lighter). If your Tibia is mostly perpendicular with resistance, the exercise is very efficient (but the weight will feel heavier).

In the illustration below, we see the side view of a man Squatting. Let’s examine how “efficient” his leg levers are. Remember that the direction of resistance is straight down (6:00 direction) - “free weight” gravity. Notice also that I’ve also placed a protractor reading at the bottom of the man’s foot, showing the angle of his **TIBIA** is 60 degrees.

A fully “**neutral**” Tibia would be 90 degrees (vertical); we call that a “ZERO lever” (**zero load** to the target muscle). A fully “active” Tibia would be horizontal; we call that a 100% lever (100% load to the target muscle). A Tibia that is halfway between vertical and horizontal (45 degrees) could be considered a 50% lever (in a simplified, non-trigonometry estimation) - halfway between zero and 100%.

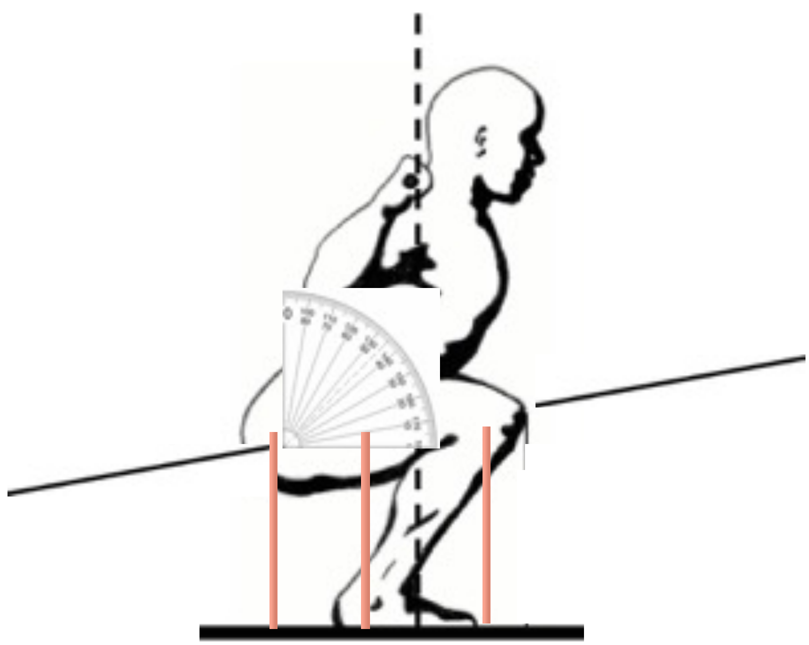
Using basic math (rather than the appropriate Trigonometry), we can make a rough estimate of how “active” this person’s Tibia is, at this particular position. A 60 degree angle is 30 degrees from the “neutral” position. Each degree (between zero and 90) is 1.11%. Therefore, this angle Tibia is (approximately) 33% active.

Again, this not entirely accurate, because, technically, a Trigonometry formula is required. However, the purpose of this book is **not** to teach Trigonometry, nor is it meant to ascertain exact calculations. It is meant to understand what is LESS and what is MORE, in terms of lever angles.

The closer the Tibia is to being parallel with resistance, the **less** percentage of the weight being used, that loads the Quadriceps. The closer the Tibia is to being perpendicular with resistance, the **greater** the percentage of the load being used, that loads the Quadriceps.

So, in the above illustration, we can see that this man's Quadriceps are only being loaded with a fraction of the weight that is actually on his back. We'll evaluate how "good" or "bad" this is, in just moment.

In the meantime, let's look at the two other "levers" operating here.



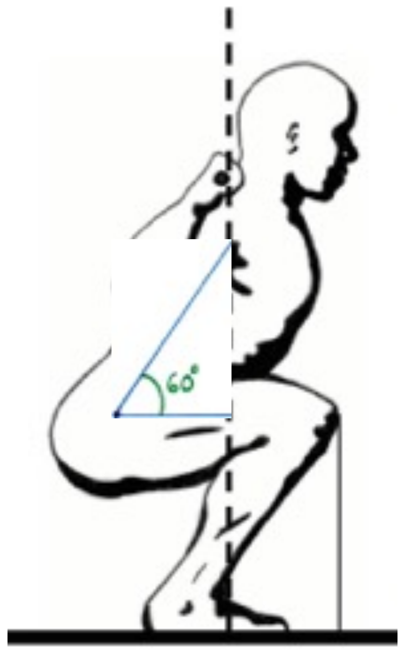
In the illustration above, I've drawn a black line through this man's **FEMUR**, with a protractor showing that it's at approximately 10 degrees. Having his femur 10 degrees below horizontal means he has passed through the 100% lever angle. Theoretically, this is good. It means that the muscle which is operating the femur (i.e., the **Gluteus,** and adductors, to a lesser degree), is getting all or most of the "available resistance".

However, as we discussed in Chapter 1, you can see that this man's Tibia (i.e., his **secondary lever** to the femur) is doubling back under the femur, which effectively reduces the femur length. I've drawn an orange line up from where his secondary lever (the Tibia) ends, and we can see that what's left of his femur length is less than half its actual length. This means the length **magnification** of his femur has been reduced.

Thus, the "available resistance" has been reduced. So, his femur is delivering - to his Glutes - 100% of a resistance that has been reduced by half. Squats do not deliver quite as much load to the Glutes as one might think.

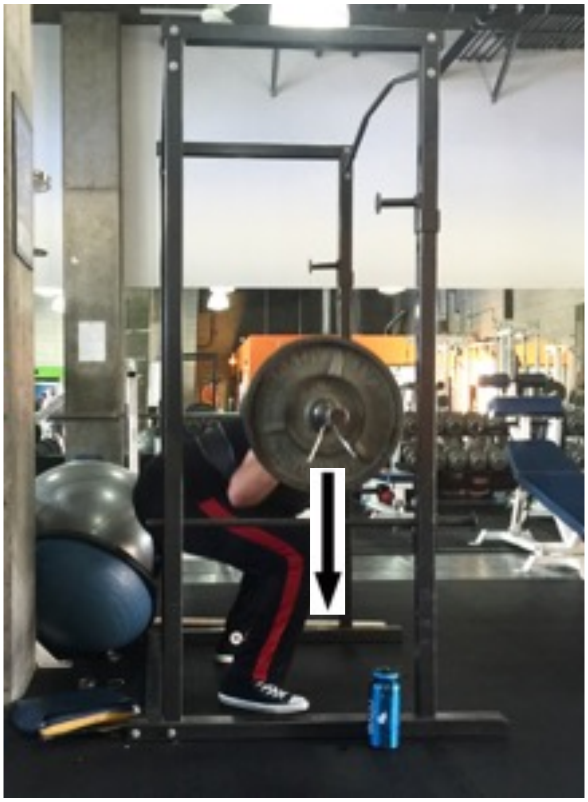
Now, let's look at one more lever which is operating here.

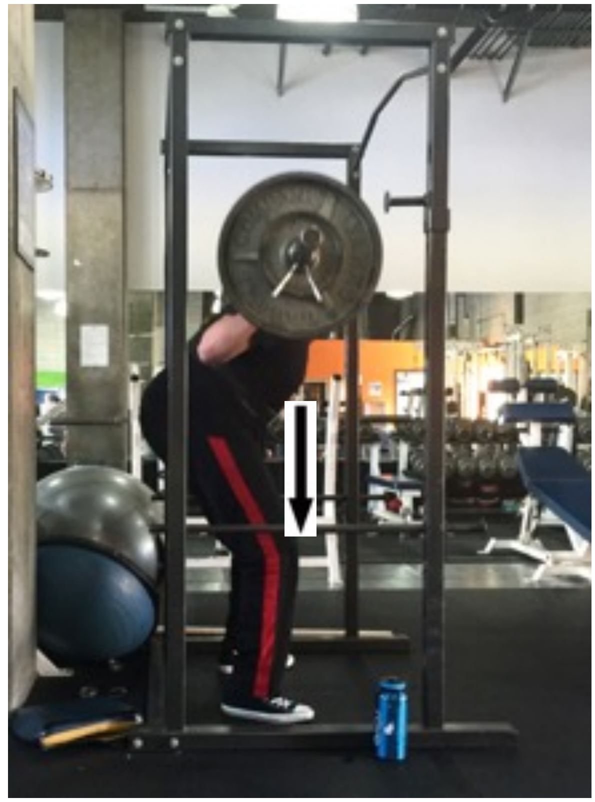
In the illustration below, we see that his **TORSO** is angled at about 60 degrees when he's at this particular position. This means that his torso is (approximately) 33% active - just like the Tibia. But his torso is longer than his Tibia, so the magnification is greater.



His Tibia and Torso are both only about 33% "active". His Tibia length is about 20 inches long, while his torso length is approximately 30 inches long. So, from this, we can surmise that his lower back is working harder than are his Quads, because of the longer torso length. His femur is the most "active lever" of the three levers, but its effective length has been reduced by the doubling back of the Tibia. His Glutes **are** working, but they're getting less than half the load they could be getting with a better exercise.

The bottom line is that - during *Barbell Squats* - the Quads and Glutes are working, but not as much as it might appear. Also, the **cost** of the exercise may be higher than the reward, because there is a tremendous amount of spinal compression and Lower Back strain, occurring during Squats - especially when a heavy weight is being used.

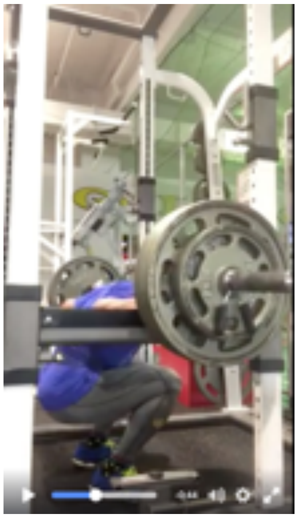




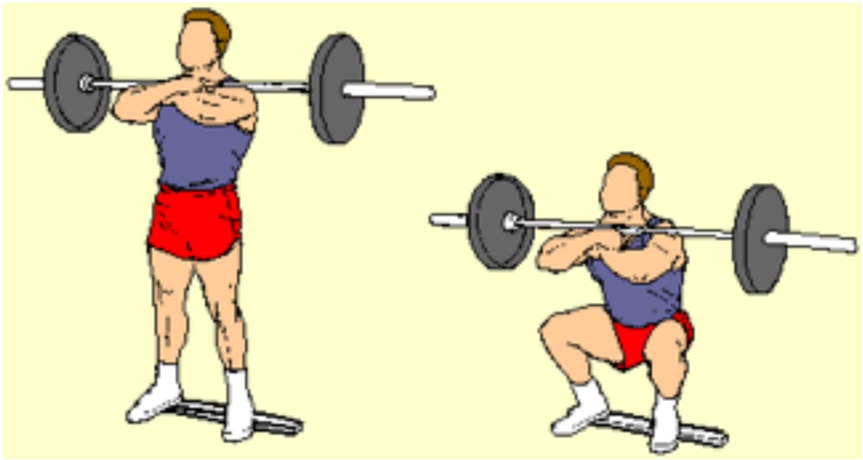
In the two photos above, we see a man performing Barbell Squats, with very bad form. It's very easy to see that his torso (lever) is more perpendicular with the black arrow (the direction of gravity), than are his Tibia. His torso lever is somewhere between a 45 degree angle (50% active) and a 30 degree angle (nearly 70% active). But his Tibia are almost entirely neutral. They are barely reaching an 80 degree angle (about 12% active), at most. His Lower Back is working MUCH harder than are his Quads.

Also, you'll notice (in the photo above-left) that he's also ROUNDING his back, at the bottom of the repetition. This is increasing the strain on the intervertebral discs - almost taunting a spinal disc herniation. Even experienced competitive bodybuilders sometimes perform their *Squats* like this. It happens quite frequently.

The four photos below are of a veteran competitive bodybuilder with over three decades of experience. And yet, you can clearly see that he's rounding his back, and also allowing his torso to tilt forward more than his Tibia are tilted forward. So, while he's barely loading his Quadriceps (due to the mostly vertical / neutral angle of his Tibia), his spine is being compressed with the full load of the 275 pounds he has on the bar, and the Lower Back is working MUCH harder than necessary.

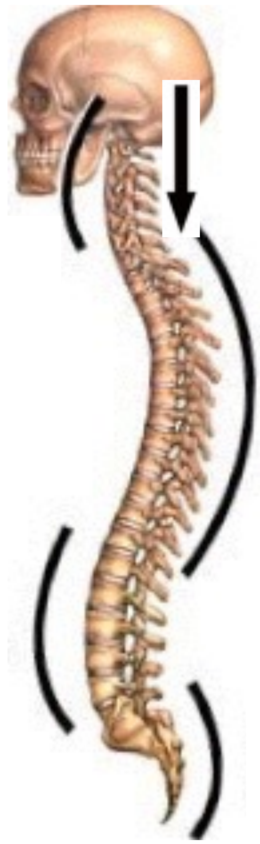
   

There are those who will now be thinking that "*Front Squats*" (shown below) would remedy this problem. Yes - *Front Squats* (holding the bar in front of the neck, instead of behind the neck) would allow a person to keep their torso more upright (i.e., more vertical), and that would alleviate some of the Lower Back strain. But it does not eliminate the downward spinal pressure, and it does not allow the Tibia to angle significantly lower than 60 degrees. So, Front Squats is still not "the solution".



Because the Tibia is prevented from angling more than 40 degrees from neutral (during standard Barbell Squats), a person will be forced to use a heavier weight than necessary, because about 57% of the weight that is on his back is NOT loading the Quads - due to the inefficiency of the Tibia levers. Yet, using a heavier weight **compromises the health and safety of the spine**. This dilemma hinges entirely on the lack of perpendicular-ness of the Tibia, during a typical Squat.

Let's take a look at the natural curvature of a healthy spine, below.



In illustration above, I've placed a downward arrow where a barbell is typically placed on the spine, during *Barbell Squats*. The bar is usually placed below the Cervical Curvature, but above the **Thoracic Curvature** (upper back) and the **Lumbar Curvature** (lower back). Now imagine what happens to these curvatures when 200 or 300 pounds is pushing downward on them. Naturally, the tendency would be for those curvatures to bend farther, like an accordion.

(Note: According to Jeremy Duvall, MS, CPT - in a 2016 article for Men's Fitness Magazine - the "average Joe" ***should*** *be able to squat 1.5 X his bodyweight. That means that a man weighing 200 pounds - who is NOT exceptionally fit - "should" be able to Squat 300 pounds. Frankly, I think this is absurd. I am a 40-year veteran of competitive bodybuilding, who is currently preparing for the World Championship. I weigh 207 pounds. I am well beyond the status of "average Joe", and yet I find Squatting 300 pounds ridiculous - not only in terms of how heavy it feels, but also in terms of spinal compression and the low benefit for muscular development.)*

If the spine was perfectly straight (no curvatures), it would be less problematic. But placing a heavy, downward force on a spine which has these curves, would naturally push these curves into more compressed and distorted angles.

Using a light weight (under 100 pounds?) would lessen the potential distortion. But using heavy weight is **very** likely to distort the spinal curvatures, at least to some degree. What kind of problems could arise from years of spinal abuse?

The illustration below shows the various problems that occur to the intervertebral discs of the spine - even to people who do not do heavy *Barbell Squats*. The top disc is "normal" (for reference), and the others show the various types of injury / damage. Disc degeneration, bulging, herniation, thinning and "osteophyte" formation (bone spurs on the vertebrae, which can then press on a nerve) are relatively common problems. Naturally, placing a 200 or 300 pound barbell on top of the spine (for Squats), every week, month after month, for years - would drastically increase the likelihood of these problems occurring.

An internet search turns up over 400,000 articles which reference "the benefits of spinal **de-**compression". This certainly suggests that **spinal compression** is a widespread problem. Should we ignore the fact that compressing the spine with 200, 300 or 400 pounds (when Squatting) is potentially disastrous for the long term health of our spine?

For the purpose of muscular development, *Barbell Squats* is a very inefficient exercise. It's absolutely foolish to place a heavy weight on the spine, but then only have **one third** of that weight actually loading the Quadriceps. Simply stated, the direction of resistance (relative to the Tibia), is far from ideal - for the purpose of developing the Quads. It results in a very low reward, but very high cost.

What's needed is a better direction of resistance.

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The exercise below is called "***Cable Squats***". Instead of using "free weight gravity", the cables (coming from a low pulley) provide a **diagonal** resistance, which crosses the Tibia much more perpendicularly.

In the photos above, look at the angle between the cable (over which I've placed an arrow, indicating the direction of resistance) and the Tibia - especially in the fully descended position. This direction of resistance makes the Tibia almost fully "active", which means it gets almost 100% of the available resistance on the Quads. Since the

Tibia gets 90 - 100% of the resistance (instead of 30% of the resistance, as in regular Squats), less weight is required. In fact, it's impossible to use the same weight in this exercise, as one would use during *Barbell Squats*. And that demonstrates its efficiency.

With *Cable Squats* (diagonal resistance), half as much weight produces as much load on the Quadriceps, as twice the weight produces with regular Squats (vertical resistance). Plus, there is no metal bar pressing down on the spine with hundreds of pounds of force. Yes - there is some degree of Erector spinae loading, but there is very little spinal compression. This exercise results in MORE of we want (Quadriceps loading and development) and LESS of what we don't want (spinal pressure).

Unfortunately, it is not as "impressive" to watch someone doing *Cable Squats*, as it is to watch someone doing heavy *Barbell Squats.* This WILL be the only reason some people will stick with standard *Squats*, and reject *Cable Squats*. Some people are more concerned with putting on an exhibition at the gym, than they are in finding the most efficient way of training. Others will simply have a hard time letting go of an old habit.

What's important to understand, is that the direction of resistance, in relation to the angle of the Tibia, plays a huge role in determining **how efficient a Quadriceps exercise is**. If a person chooses a Quad exercise where the Tibia is mostly "neutral" (i.e., mostly parallel with the direction of resistance), then that person will HAVE to use much more weight in order to provide their Quadriceps with enough load. However, using such heavy weights will surely take its toll on the spine, knees and hips. And it's **not necessary**, for optimum Quadriceps development.

Using a direction of resistance that allows a person's Tibia to be more "active" (more perpendicular with resistance), provides more load to the Quads, and much less load on the spine - and that's training wisely.

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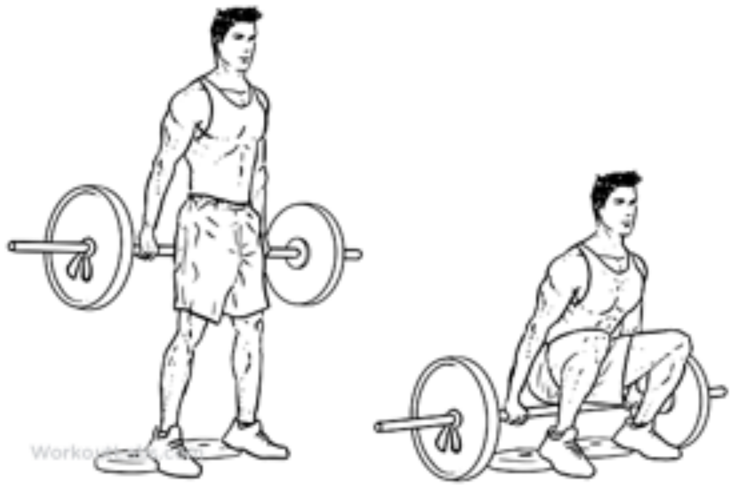
Let's look at some other Quadriceps exercises, and see how efficient they are. Keep in mind, "efficient" means that a greater percentage of the weight used will be loaded onto the Quadriceps. "IN-efficient" means that a lesser percentage of the weight will be loaded onto the Quadriceps - EVEN if more weight is being used. In fact, it is the "inefficiency" of certain exercises (like Squats) that allows so much weight to be moved.

Hack Squats

The original "Hack Squat" (common in the 40s, 50s and 60s) was done by holding a barbell behind one's buttocks (arms straight), and then performing a squatting movement (below).



This really is an “Old School Exercise”, in the sense that we rarely see anyone doing it this way anymore. The intention was to take the barbell OFF the spine (a good idea), and place it lower - thus allowing the torso to be more upright. This would alleviate the strain on the Erector spinae. So, you see - even back then - SOME people were trying to find a remedy to the problem of placing a heavy weight on the spine, during regular *Barbell Squats*.

Unfortunately, this exercise is very uncomfortable. It’s difficult holding a barbell in this position. Plus, when the person gets to the bottom, the barbell swings underneath the buttocks. As we try to stand up, the bar must be pushed back, so we can stand up without obstruction. This made it difficult to use a substantial weight.

Then the “Hack Squat Machine” (below-left) was invented. But it only partially solves the problem.

Whether we're talking about an Old School *Barbell Hack Squat*, or a *Machine Hack Squat* - or even a *Front Squat* (shown below) - the objective of these "Squat alternatives" is to eliminate the leaning forward of the torso, thereby reducing the involvement of the Lower Back (Erector spinae).

But that's only PART of the problem. In most of these cases, two other negative factors persist - a mostly neutral Tibia (which reduces the load to the Quadriceps), and the resulting consequence of having to use MORE weight (to compensate for the mostly neutral Tibia) - which then pushes straight downward on the spine. This is true even if a machine has "shoulder pads". They are still pushing downward on the shoulder carriage (the scapula / clavicles), which compresses the spine.

Notice, with the *Hack Squat machine* and *Front Squat*, the difference between the black arrow (which is indicating the direction of resistance) and the Tibia. In both cases, they are almost parallel. In other words, in both cases, the Tibia is mostly "neutral".

Now, go back and look at the direction of the Cable resistance, and the Tibia, in the *Cable Squat* photos above. They're not entirely perpendicular, but they're far more "active" (perpendicular) than the B*arbell Squat*, the *Hack Squat*, the *Front Squat*, and the *45 degree Leg Press* (shown below).

45 Degree Leg Press

In the photo below, the arrow is showing the direction of the sled. That represents the direction of resistance. Notice the Tibia is almost parallel with the direction of resistance / the arrow. The Tibia is barely "active" - maybe 20%. This means that - in order to adequately load the Quadriceps - a considerable amount of weight must be used. But that is ONLY due to the inefficiency of the mechanics of the exercise. If the Tibia were 60% active, a lesser weight would load the Quadriceps just as much, or more.

If the feet were placed lower on the platform, it would cause the Tibia to be **more perpendicular** with the direction of resistance, and it would cause the knees to bend more (better range of motion). This would improve the exercise a bit, but it still would not make this exercise “great”.

Once the feet are placed lower on the platform, it will be almost impossible to keep the heels flat on the platform, in the descended position. This would make the footing very uncomfortable. Some Leg Presses only allow a high foot placement, because the foot plate doesn’t extend down low enough.

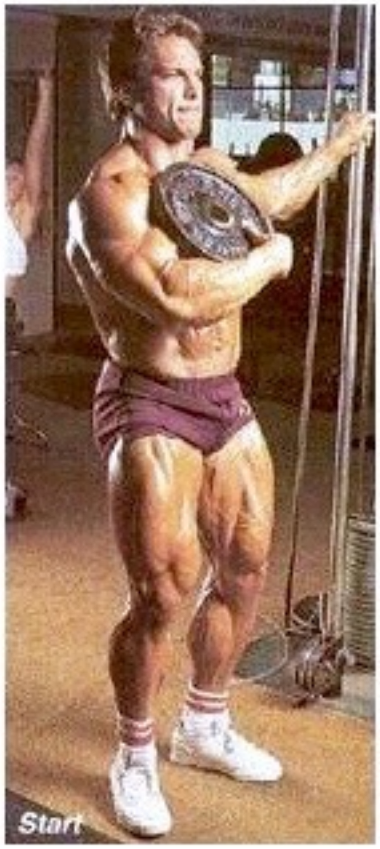
Notice also that his thighs are almost touching his torso, yet his knees are only bent at about 90 degrees. If this person had a larger belly, he would not be able to bring his thighs down as low, and his knees would be bent even less - maybe on 70 or 80 degrees. Ideally, the knees should bend beyond 90 degrees, when in the descended (stretch position) of a Quadriceps exercise. I’d recommend always putting the seat back as far as possible, thereby giving your knees as much clearance as possible. But there’s still another problem with this exercise.

When we perform a Squat (bodyweight or otherwise), “proper form” requires us to keep our back arched. However, when doing a Leg Press, this is almost impossible - except in the starting position. By the time the sled is half way down, our tailbone has begun curling under - thereby “rounding” the Lower Back. If heavy weight is being used (as is usually the case with advanced / ambitious bodybuilders), this will strain the spine.

Go back up and look at the Cable Squats. See how the spine is kept arched, and the tail bone is kept back. That spinal posture is impossible to maintain when doing Leg Presses. In fact, as an experiment, try bending over (while standing), so that your torso is parallel with the floor. Now do 20 reps of Squats - while **keeping** your body piked that way, the entire time. That is essentially what we're doing when we do 45 Degree Leg Presses - "*partial knee and hip extension, while bent over at the waist*". We should acknowledge that that movement is anatomically compromised, and dismiss the 45 degree Leg Press as an inferior and inefficient exercise.

Sissy Squats

This exercise below, is called a "Sissy Squat", but it's definitely NOT for sissies. It's a very challenging exercise, precisely because it's VERY efficient. In fact, it's likely too efficient for most people - meaning they'll probably find it too difficult - even when using NO WEIGHT at all. The reason? The Tibia is maximally efficient. It goes more perpendicular (with resistance) than any other Quadriceps exercise.



In the photo above-right, notice how perpendicular the angle of the Tibia is, relative to the black arrow (the direction of resistance). That's a very "active" lever ! Go back and compare THAT degree of "active" (perpendicular) with the Tibia angle of the Leg Press, the Hack Squat, the Front Squat, and the Barbell Squat.

Not all Quadriceps exercises need to have quite this degree of "perpendicular-ness", but the Tibia should be **mostly** perpendicular, rather than mostly parallel (with the direction of resistance), in the Quadriceps exercises we select, in order to be optimally efficient.

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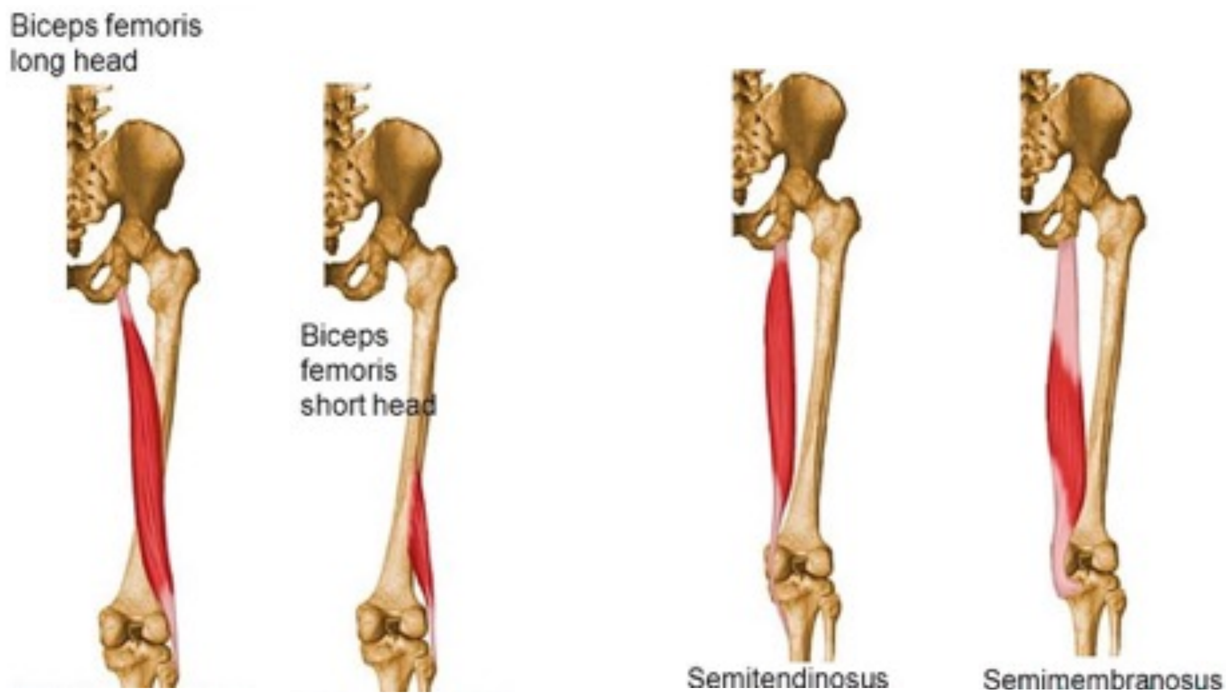
Hamstrings

The “Hamstrings” is the common name used to refer to the four muscles on the back of the thigh. It is compromised of the **Biceps femoris** (short head and long head), the **Semimebranosus** and the **Semitendinosus**.

Aesthetically speaking, well-developed Hamstrings provide a balanced “sweep” between the front and back of the thigh, when viewed from the side. When viewed from the back, well-developed Hamstrings would show clarity and definition.

The **primary** function of the Hamstrings is knee flexion (bending the knee - bringing the lower leg downward / backward). The secondary function of the Hamstrings is hip extension, but they are much weaker in that capacity as compared with the Gluteus maximus and the Adductors. So, although they **assist** in hip extension, they are not the primary hip extensor.

In the illustration below, we can see origins and insertions of the four parts of the Hamstrings.



In the illustrations above, we are looking at the right leg, seen from the rear (posterior view) - as if the person is looking away from us.

The two illustrations **above-left**, show the **Long Head** and the **Short Head** of the **Biceps Femoris**. As you can see, the Long Head originates on the pelvis and the Short Head originates on the Femur itself. Both of these “heads” then insert onto the head of the Fibula (the thinner of the two lower leg bones).

The two illustrations above-right, show the **Semintendinosus** and the **Semimembranosus** - which are the two inner parts of the Hamstrings. Both of these heads originate on the Ischial Tuberosity of the pelvis, and then insert onto the top portion of the Tibia (the larger of the two lower leg bones).

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The Ideal Motion

Unlike traditional Quadriceps training - where there has been more "wishful thinking" and confusion about how which exercises are best - training the Hamstrings has been fairly straight forward. "Leg Curls" - usually the prone (face down) version - has been the standard exercise for decades. Yes, "Standing Single Leg Curls" and "Seated Leg Curls" have been also been included, but the most consistent exercise performed - and the machine that almost every single decent gym in the world has - is the Prone (lying face down) *Leg Curl*.

The only really "odd" exercise that has been used for Hamstrings is the *Straight Knee Deadlifts*.

Some people believe that "***Straight Knee Deadlifts***" (shown below) are effective for Hamstring development. They believe the "evidence" of this is that they feel their Hamstring stretch when fully descended, and that they feel soreness the next day. However, if the mechanics of a *Straight Knee Deadlift* are good for the Hamstrings, than those same mechanics would be good for other muscles as well - but they're not.

The “mechanics” of the Straight Knee Deadlift are as follows”

1. The sole pivot point is the hip joint
2. Hamstring “contraction” requires knee flexion - yet there is none in this exercise
3. The Gluteus maximus, minimus and medius - along with the Adductors - are the primary hip extensors, so they will automatically do most of the work
4. Hip flexion (especially with a flat back) stretches the Hamstrings

As a comparison, let’s look at the Biceps of the arm. After all, the Hamstrings are essentially the Biceps (femoris) of the Legs. Both of these cross two joints. The Biceps of the arm crosses the elbow (primarily) and the shoulder (secondarily). The Hamstrings crosses the knee (primarily) and the hip (secondarily).

To work the Biceps of of the arm, we flex (bend) the elbow. That would be the equivalent of a *Leg Curl*, for the Hamstrings.

If we pull the humerus (upper arm bone) back - with the elbow straight - we stretch the Biceps. But would we ever think that stretching the Biceps, without flexing the elbow, would “build” the Biceps? That’s the equivalent of a “Straight Knee Deadlift” - stretch without contraction. Can we make a muscle sore from forceful stretching? - absolutely. But soreness is not a good indicator of productive muscle stimulation.

If we only stretched (with resistance) our Pectorals - but did not contract them - it would not produce much (if any) noticeable muscle hypertrophy. The same is true with every voluntary skeletal muscle in our body. Muscular development requires muscle contraction - not only muscle stretching.

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When we were reviewing the “ideal” anatomical motion for the Biceps, we established that elbow flexion was absolutely required. The question was, “what’s the best humeral position”, while flexing the elbow?

The same is true here, with regard to the Hamstrings. We’ve already established that knee flexion is required. The question is, “what’s the best femoral position”, while flexing the knee? The answer here is similar to that of the Biceps.

You might recall, that - for Biceps - the “ideal” humeral position while elbow flexing is one that avoids stretching the Triceps simultaneously. Likewise, the “ideal” femoral position for training the Hamstrings, is one that avoids Quadriceps stretching. We discussed this in Chapter 12 (Reciprocal Innervation).

I realize some readers might be remembering the guideline that encourages producing movement in an anatomical position that is “as close to natural as possible”. Some might think that - for Hamstrings training - this would mean keeping the femur parallel to the torso. However, it appears that the Hamstrings were not meant to be fully flexed, while the Quadriceps are fully stretched. We can test this for ourselves, as we did in our earlier experiment. Rather, it seems the Hamstrings were meant to be fully flexed when the Quadriceps are relaxed enough to allow it - and that requires a degree of hip flexion.

Few people would argue that it’s difficult to keep our tailbone from rising, when doing Prone Leg Curls. This tendency is caused by the body’s automatic effort to prevent over-stretching the Quadriceps. In fact, this is hardwired into our system. The “Reciprocal Innervation” safety mechanism - to a degree - “forbids” the full activation of a muscle, while its opposing muscle is contracting, or otherwise presenting a conflict of interest. Quadriceps “stretching” is a conflict of interest to the full activation of the Hamstrings.

For this reason, it is best to work the Hamstrings with a machine (or in a position) that allows the hips to be bent at an angle between 45 degrees and 70 degrees. A fully piked position (90 degree angle bend at the hip) would likely over-stretch most people’s Hamstrings when they are fully elongated. It seems that an angle between 45 degrees and 70 degrees is more than sufficient to prevent Quadriceps stretch during Hamstrings contraction, without forcing too much Hamstrings stretch at full extension.

This degree of hip angle could be achieved several ways - including a Prone Leg Curl machine that simply has a more dramatic “rise” under the hips. Years ago, “Nautilus” made a Leg Curl machine that placed a person on his/her side - and the knee flexion was performed from that angle. Today, the most obvious choice would be a standard “*Seated Leg Curl*” machine.

A well-designed Leg Curl Machine allows for the appropriate hip flexion, so there won't be any "conflict of interest" with the Quadriceps. Also, it would allow for Range of Motion options. Given that the Hamstrings experiences a significant amount of "Mechanical DIS-advantage when the knee is straight, it is essential that the final 10 to 20 degrees of the Range of Motion be restricted, when using heavy weight. A well-designed CAM (cable mechanism) would also help in this regard, by providing the "ideal" resistance curve.

I’d rate a well-designed ***Seated Leg Curl*** a “10”, for effectiveness and safety, and a *Prone* (mostly flat) *Leg Curl* a “7”.

I’ve been doing the *Seated Leg Curl Machine* exclusively for almost two years, and have been getting better results than ever. Given the two options (*Seated Leg Curl* and *Prone Leg Curl*), I’d never use a Prone Leg Curl Machine now. The “Seated” version is much better - more comfortable, more efficient and more safe.

If a person does not have access to *Seated Leg Curl* machine, but has access to an adjustable pulley, he/she might try rigging up some kind of *One Leg /* ***<u>Cable</u>*** *Leg Curl* exercise (using a D-Ring ankle strap), while sitting on a flat bench (facing the pulley). In the absence of a Seated Leg Curl, and an adjustable pulley, I’d “settle” for a *Prone Leg Curl* - but I would try to put some kind of lift under my pelvis, if possible.

What I would NOT do is either of the two exercises below.



These two exercises might seem perfectly innocuous - but there's a hidden danger, as well as a compromised benefit.

In both cases - although more so with the strap version - when the legs are straight, there is an enormous amount of Mechanical Disadvantage occurring at the knee / Hamstring angle. From this angle, the Hamstring is only able to pull on the lower leg from a severe parallel angle. As we know, the force requirement - when this happens - could be as much as six fold. This, in combination with a maximally active lever - which is precisely what's happening here - could easily cause an injury. Let's do some basic math.

Given the angle of his body - relative to gravity - it's safe to say that he's suspending about a third of his bodyweight by his heals, and two thirds on his shoulders / upper back. If this man weighs 150 pounds, that would mean he's suspending 50 pounds by his heals - 25 pounds with each leg.

However, that 25 pounds per leg is magnified by the length of his lower leg. The average Tibia is 17 inches long. To be safe, let's use a factor of 15. Twenty five pounds X fifteen = 375 pounds, per leg. But that's at a Mechanical Advantage. That's how much the Hamstrings would have to pull, if they could pull on the lower leg PERPENDICULARLY - but they can't. Mechanical Disadvantage could require as much as 6X more force, making the total load on the Hamstring / knee 2,250 pounds - per leg.

If the Hamstrings are not able to produce the required force, the "responsibility" (to bear the load) would fall onto the tendons and ligaments of the knee. And - since the knee won't bend in the reverse direction - this exercise is essentially forcing the knee to hyperextend in a direction it was not designed to bend.

Needless to say, attempting either of these exercises with a SINGLE leg, would be very foolish. It would double the load per knee / Hamstrings.

The force (resistance) on the knee / Hamstrings is greatest when the knees are straight and the legs are extended - which is very dangerous. Once the heels have been brought in, the knees are bent and the distance between the knees and the heels is diminished, it's very safe - even if not very productive. The resistance diminishes too much, toward the end of the range of motion.

Part of the problem here is that these are "bodyweight" exercises - it's all or nothing. It would be much better for a person to have total control over the weight being used, as would be the case when using a "selectorized" (weight options) *Leg Curl* machine. This is another example of why many of these "functional" exercises are NOT so good, and many isolated exercises ARE good.

Chapter Twenty-Three

Glutes, Adductors & Hip Flexors

The “Glutes” are comprised of three individual muscles - the **Gluteus maximus**, the **Gluteus medius** and the **Gluteus minimus**. These latter two lie <u>underneath</u> the Gluteus maximus, and are therefore referred to as “deep muscles”. In the illustration below, we can see all three muscles and their location.

GLUTEUS MAXIMUS   GLUTEUS MEDIUS   GLUTEUS MINIMUS

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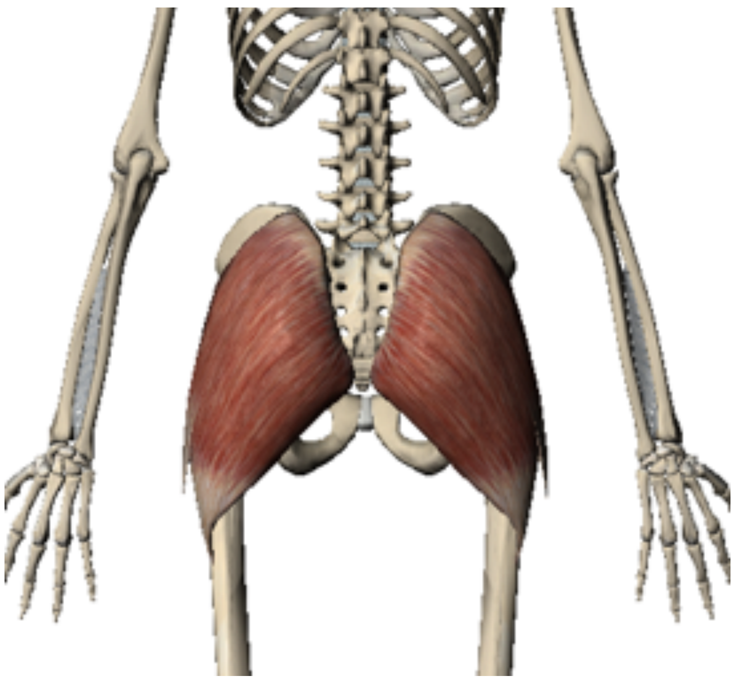
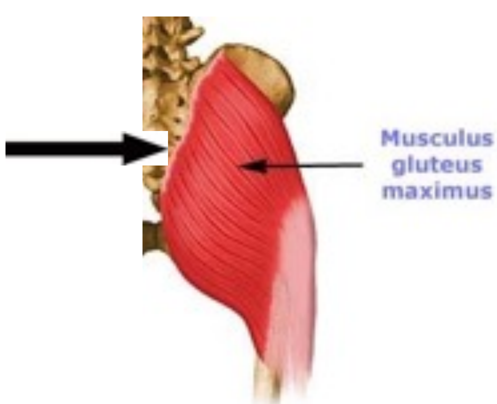
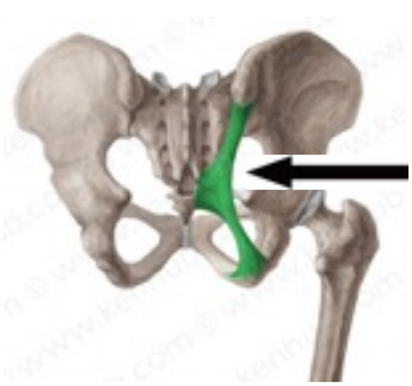
Gluteus Maximus

The muscle that is most significant to the bodybuilder, or the person pursuing physique development, is the Gluteus Maximus - shown below.

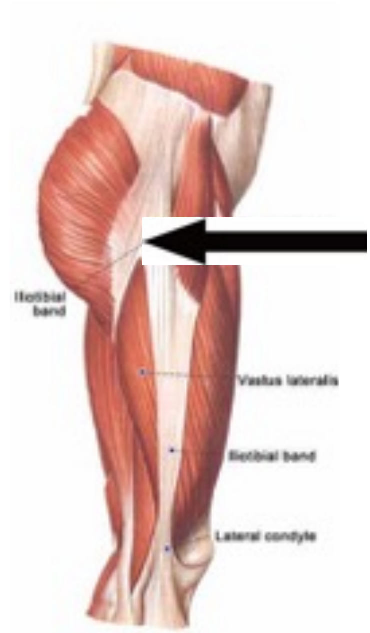


Most of the origins of this muscle are on the “Gluteal surface” of the Ilium - the inside edge on the posterior side of the pelvis, close to the spine. Some of its other fibers originate on the Lumbar (spinal) fascia; others on the sacrum (base of spine), and others on the “sacrotuberous ligament” (shown in green, below-right).





These fibers then insert onto the Gluteal Tuberosity of the femur (below left) - just below the Greater Trochanter - and also on the Iliotibial tract (shown below-center and right).



The Gluteus maximus “extends” the hip joint - which means that it **pulls the femur** (shown as a red line below) **downward** and **back** (posteriorly), from a position in front of us.

In addition to hip extension, the Gluteus maximus also externally rotates the femur. This is obvious by the diagonal direction of the fibers, as well as the fact that the muscle insertion is lateral to the origin. When the insertion moves toward the origin, it would naturally tend to rotate the femur externally.

The action of “hip extension” is not performed solely by the Gluteus maximus, however. Another prime mover - the Adductors - participate in this action. This will be discussed shortly.

The Gluteus maximus develops fairly easily for most people, simply by doing *Lunges*, *Squats* or *Glute Extensions*.

It’s worth noting that performing exercises for the Gluteus maximus (or medius or minimus) WILL NOT REDUCE BODY FAT FROM THAT AREA. This includes bodybuilders trying to “etch” Gluteal striations.

The fibers of the Gluteus maximus become visible only when one’s body fat is low enough. Those fibers are not visible otherwise, regardless of how well developed the muscle is. A person could have quite a lot of Gluteal muscle, but the fibers would not be visible if the person’s total body fat is not low enough (above 5%, generally speaking). Conversely, a person could have very little Gluteal fiber thickness, but - because they are so lean - they’re Gluteal fibers are very visible - as is the case in the photos below.

Getting lean is a SYSTEMIC process (whole body) that involves caloric deficit. It cannot be done “locally” - in specific areas of the body.

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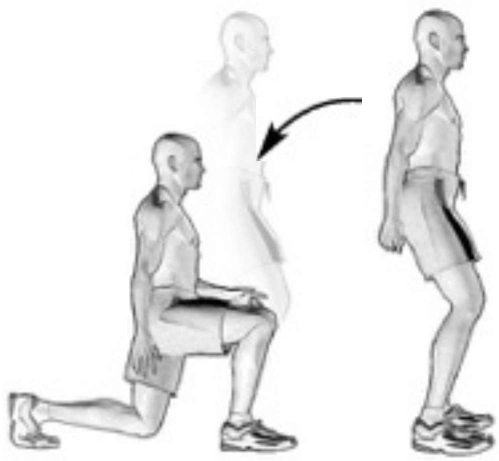
The best exercises for the Glutes, include the following:

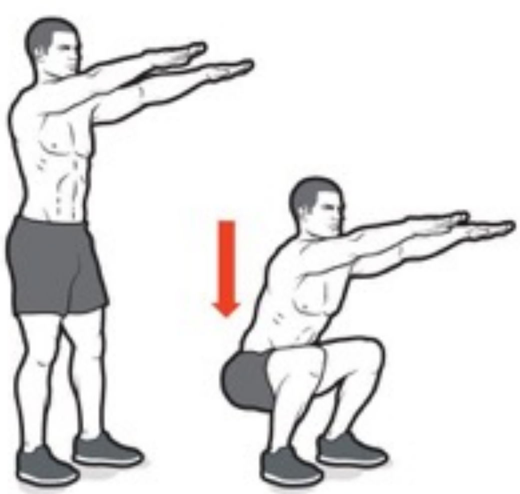
1. Multi-Hip Machine / Glute Extensions

2. Cable Squats

3. Back Lunges and/or High Bench Step-Ups



4. Freehand Squats



5. Floor Bridges (Using both legs for stability. Placing a moderate resistance on the hips is acceptable.)

6. “External Femoral Abduction” (also known as the “Outer Thigh” Machine)

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The exercise below - “*Barbell Hip Thrust*” - is **conceptually** good. Allowing one’s hips to drop lower than the upper back, thereby reaching a 90 degree bend at the hip joint, before pushing to a contracted position, is theoretically good. However, it requires a bench that is bolted to the ground, so it won’t slide back or tip over. It also creates a pressure point on the upper back (on the spine) which could be very uncomfortable. Placing over 100 pounds on the pelvis is also not comfortable, and it’s very cumbersome getting into position for this exercise. Yet, it’s no more beneficial than the first three exercises shown above, which are much easier to do.

 

Barbell Squats and Deadlifts are also not in my “top six” exercises for Glutes, even though they do build the Glutes. I just feel the “cost” of these exercises is too high, compared to the benefits. The exercises I’ve listed as the “top six” work VERY well, without the inefficiency and injury risk of Barbell Squats and Deadlifts.

It’s also important to be realistic, in terms of how well-developed one’s Glutes CAN get. If a person is not satisfied with the degree of Gluteal development they have achieved with exercises like the ones I’ve listed as the “top six” - it’s understandable that they might **think** Barbell Squats and heavy Deadlifts may be the answer. I believe that is an incorrect assumption. If one’s Glutes do not grow as much as they would like with the six exercises above, it is unlikely that person’s Glutes will grow any more with Barbell Squats and heavy Deadlift. We all have our genetic limitations.

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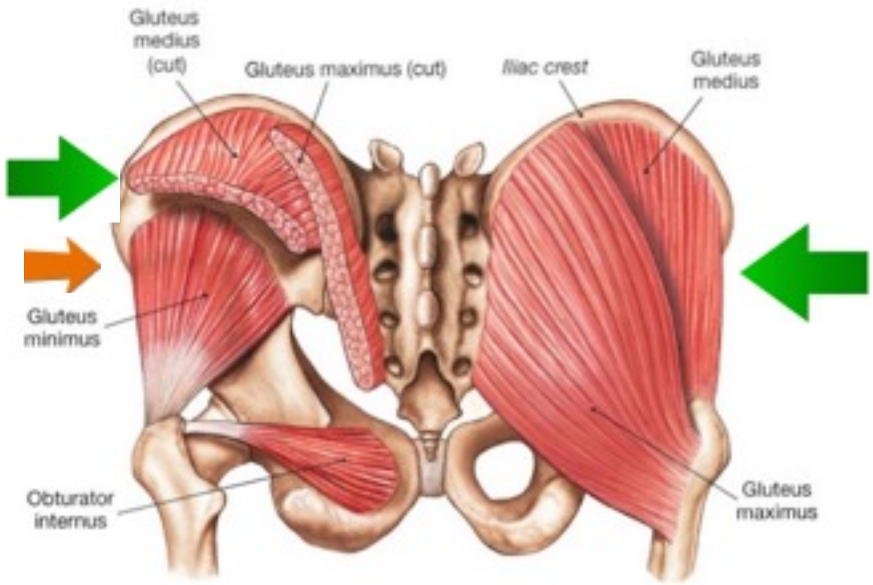
Gluteus medius & Gluteus minimus

In the illustration below (posterior view), I’ve place a green arrow pointing to the Gluteus **medius**. The left side of the illustration shows how the Gluteus medius lies OVER the Gluteus **minimus** (orange arrow). The right side of the illustration shows how the Gluteus medius lies UNDER the Gluteus maximus. The Gluteus medius and minimus both attach onto the Greater Trochanter of the humerus. The black arrow is pointing to the Greater Trochanter of the femur, below-right.

The vertical fibers of these two muscles suggest that they participate - along with Gluteus maximus - in hip extension. However, because their attachment is higher and more lateral on the femur - as compared with the Gluteus maximus, they don’t have quite the same degree of leverage in that movement. They do participate in hip extension, but their primary function is more in the realm of lateral abduction of the femur (sideways leg movement).



The Obturator internus (seen above), along with the Piriformis, the Gemellus inferior and Quadrates femoris - other “deep” muscles that lie underneath the Gluteus maximus - act mostly as “anchors” of the humeral head. They mostly ensure that it stays in socket, but they also assist in rotation of the femur.

The Gluteus medius and minimus are not considered primary “physique muscles” because they have almost no have capacity for growth. Functionally, these muscles already participate in movements that engage the Gluteus maximus, so they do not need to be directly targeted with resistance exercise. However, the “Outer Thigh” machine would be the best movement, if one chooses to work these muscles directly.

It should be noted, that some people who use an “Outer Thigh” machine, mistakenly believe they are “targeting fatty deposits on the upper part of their thigh”. In fact, the “Outer Thigh” does nothing for local fatty deposits.

The concept of “spot reduction” - the belief that a person can cause the fatty deposits of a selected area of their body to dissipate, is fantasy. Body fat loss only happens systemically (as a whole) - not in the area of one’s choosing.

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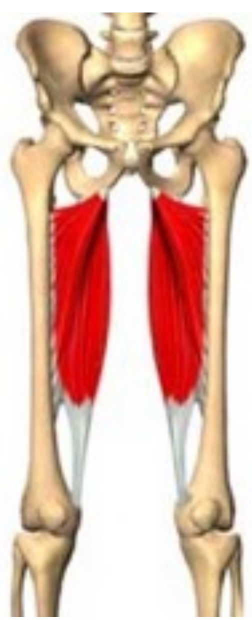
Adductors



The Adductor muscle group is relatively misunderstood from the layman's perspective. Some people (mostly women) believe working this muscle is the way to dissipate localized fat on the inner part of their thighs. Of course, this is impossible. Other people view this muscle group as "unimportant", believing it only brings the femurs together. In fact, the Adductors do more than just bring the femurs together.

The Adductors play a significant role - along with the Gluteus maximus - in hip extension. So, functionally, they are very important. Visually, the help balance the musculature of the upper legs.

In the photo above, I've placed a red arrow pointing to the Adductors of the right leg, and a green arrow pointing to the Gluteus maximus of the left leg. I've done this to show how **both** of these muscles might participate with each other, in pushing the femurs downward. Since the insertion of the Gluteus is **only** on the outside of the femur, there would need to be a muscle lending a balancing force on the inside of the femur, sharing the "downward femur pushing" task. Otherwise, full activation of the Glutes would cause an almost stronger external rotation of the humerus, than a downward hip extension. The Adductors seem perfectly suited to lend this **internal** / downward force, to balance the Glutes **external** / downward force.

Interestingly, most lay people who look at the photo above, think they are looking at a pair of very sell developed Hamstrings. However, this person's Quadriceps, Glutes and Adductors are much more well-developed than are his Hamstrings. And he's very lean, of course - which helps see the various muscles with good clarity.

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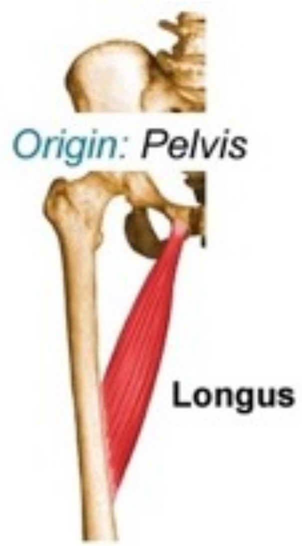
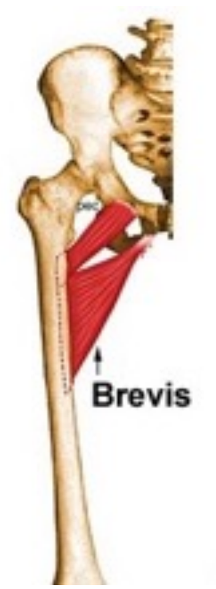
There are three major parts of the Adductor muscle group - the **Adductor Magnus** (below-left), the **Adductor Longus** (below-center) and the **Adductor Brevis** (below-right). The Magnus plays the most significant role, given its very low insertion on the femur, followed by the Longus and the Brevis. All three parts originate on the pelvis - mostly on the **Ischium** - and all three parts insert onto the femur - low, middle and high.





Yes - the Adductors ALSO pull the femurs inward, in addition to participating in hip extension. However, most of us have experienced “inner thigh” soreness, a day or two after doing Squats. It’s obvious that the Quads and the Glutes would be sore a couple of days after Squatting. But most people don’t realize that without the help of the femoral Adductors, it would be difficult to prevent the knees from rotating outward, while Squatting. They keep the femurs from rotating outward, and they also help pull the femurs downward.

Therefore, there is no need to perform any kind of “inner thigh” / Adductor exercise - at least not for the sake of bodybuilding, fitness and general conditioning.

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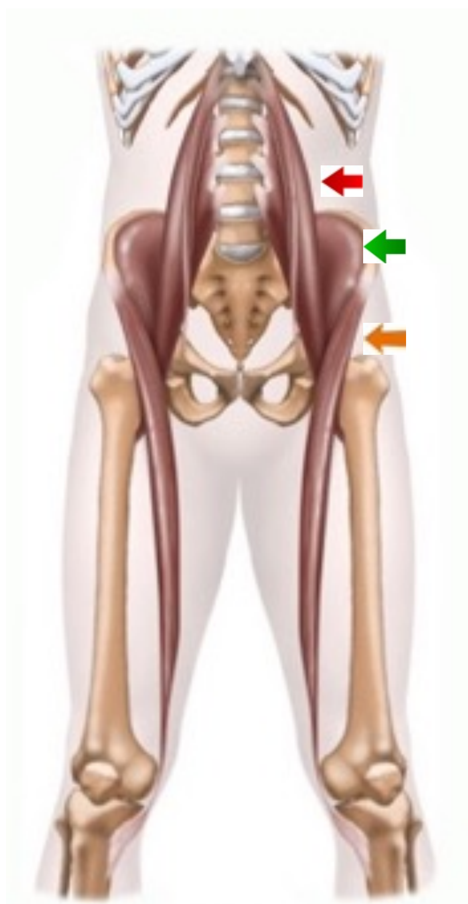
Hip Flexors



The Hip Flexors are comprised primarily of three muscles - the **Psoas** (red arrow above), the **Iliacus** (green arrow above), and the **Sartorius** (orange arrow above). To a lesser degree, it also includes the **Rectus femoris** and the **Tensor fascia lata**, which we'll look at in just a moment.

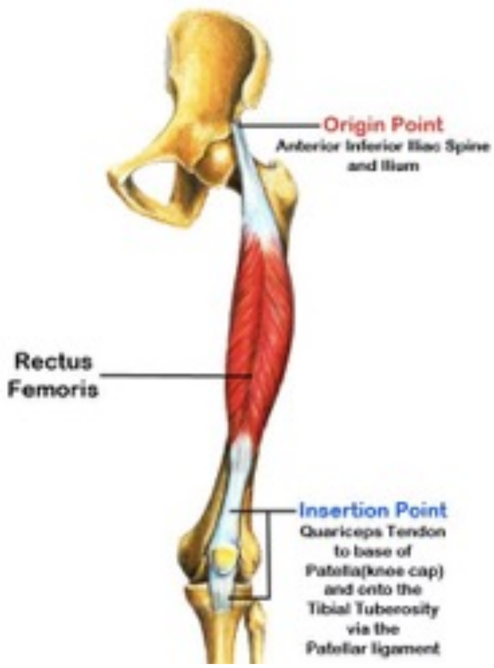
The Psoas is a two-part muscle: the Psoas major and minor, but the "minor" is SO minor, as to almost be not worth mentioning. The Psoas and the Iliacus are collectively known as the "**Iliopsoas**" (pronounced: ILIO-SOAS, with a silent P).

In the illustration below-left, you can see that the Iliacus originates on the pelvis, and the Psoas originates on the base of the spine. This is important, because when people who are doing Leg Raises feel "lower back pain", it's often due to the Psoas pulling directly on the spine. The combined "Iliopsoas" then connects onto the **"Lesser Trochanter"** of the femur, shown below-right.

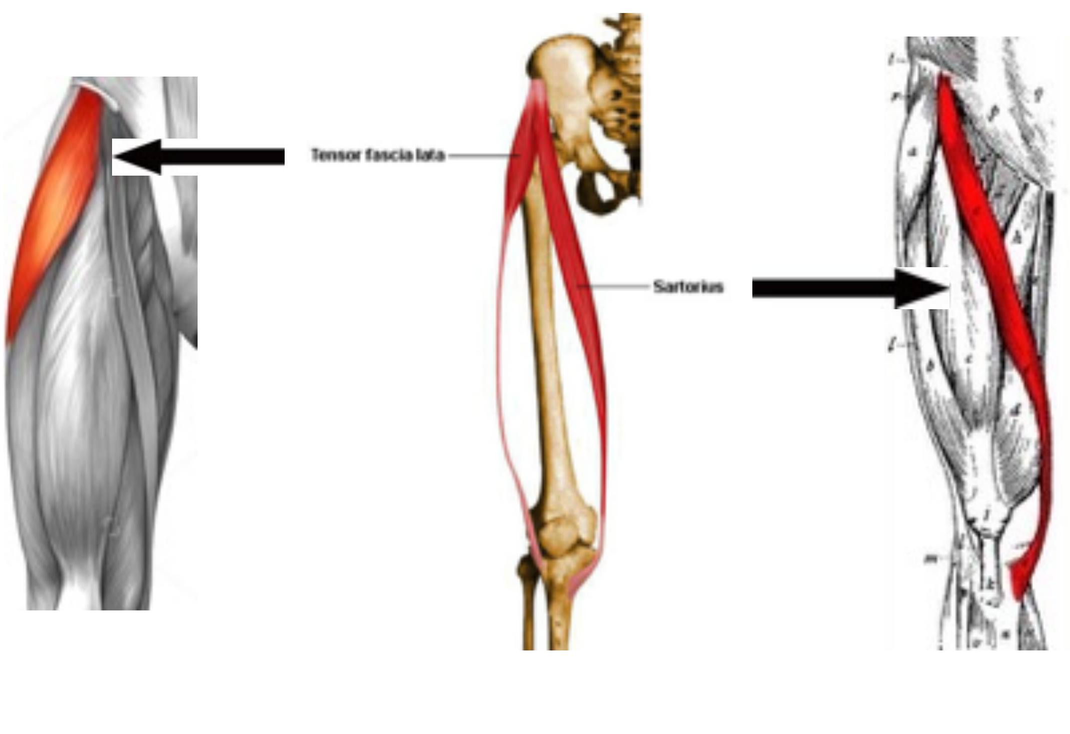
When we do Leg Raises - whether hanging from a Chinning Bar, flat on the floor or on an Incline Bench - it's the Iliopsoas that is doing the majority of the work. It is NOT the abdominals. The Iliopsoas are assisted in the task of raising the legs (pulling the femurs forward and upward) by the Sartorius, the Rectus femoris and the Tensor fascia lats. The Abs don't even assist in raising the legs, because they are NOT connected to the legs.

(Note: The Abs only participate in Leg Raises by maintaining posture in the spine, while the legs are raised. Without the Abs maintaining spinal rigidity, the tailbone would kick backward, in response to the forward movement of the legs ("for every action, there is an equal and opposite reaction" - Sir Isaac Newton). The Abs prevent that from happening, by way of isometric tension. It's true that the Abs might produce a small amount of dynamic pelvic push (spinal flexion), but the primary movement - during Leg Raises - is hip flexion.)

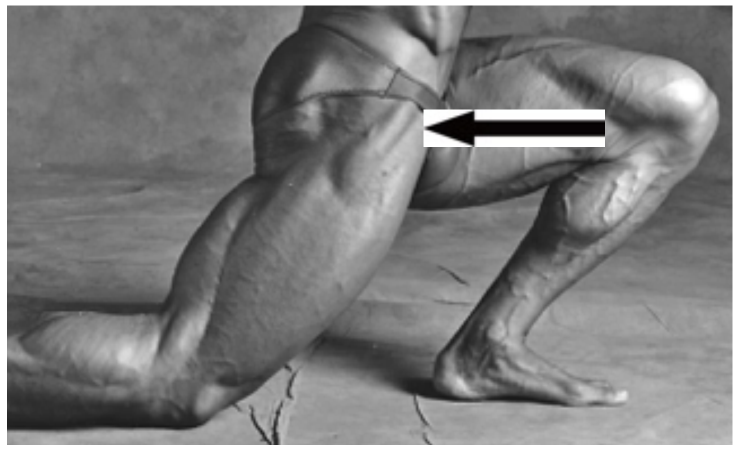
In the Quadriceps section, we established that one of the four Quadriceps muscles - the **Rectus Femoris** (shown below) - is the only one which **crosses** the hip joint. This allows this muscle to assist in help flexion, but it's a very minor role. It's primary function is still knee extension.



There are two other muscle that also assists in hip flexion: the **“Sartorius”** and the **“Tensor Fascia Lata”** - both shown below. Neither is a powerful hip flexor, as they are string-like. The Tensor Fascia Lata is a short muscle that pulls on the **Iliotibial band**. Both of these muscles extend down past the knee joint, similar to the Rectus Femoris. This seems to suggest that both are meant more as “coordinators / sensors” that help coordinate hip flexion and knee extension. The Sartorius also plays a small role in externally rotating the femur, given its crossing from the outside of the leg, to the inside of the Tibia.



It's nice to see a bodybuilder with a clearly visible Sartorius (below left) and Tensor fascia lata (below right). However, their visibility (i.e., clarity) relies more on one's overall level of leanness, than on how "well developed" these muscles are. If one is lean enough, both will likely be visible. If one's leanness level is not low enough, neither is likely to be visible, regardless of how well developed these muscles are.



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Should we work our hip flexors?

Assuming we now understand the foolishness of doing any kind of Leg Raise exercise **for the purpose of working the <u>Abs</u>**, the question now is - "Is there a benefit to working the Hip Flexors, for their own sake?".

Functionally speaking, it's good to keep them moderately strong - but that can be done simply by taking the stairs frequently, or by doing "***High Steps***" (10 to 20 inches high) - either as part of our Gluteus workout or as a Cardio exercise. Obviously, the stepping should be done with alternating legs, so both legs get equal work.

In terms of “visible development”, only three of these five muscles (the Rectus femoris, the Sartorius and the Tensor fascia lata) are “superficial”. The **Iliacus** and the **Psoas** are “deep” muscles, and are never visible.

The **Rectus femoris** already gets plenty of stimulation from Quadriceps exercises and does not benefit much from hip flexion. That leaves two remaining hip flexors which could be visible - the **Sartorius** and the **Tensor fascia lata**.

Now, take a look at the two photos above - the one showing the Sartorius (above-left) and the one showing the Tensor fascia lata (above-right), and you’ll realize that these are “detail” muscles that only matter in advanced bodybuilding. Few people ever get lean enough to have these muscles be visible, and having them be visible is only worthwhile to the most fanatic connoisseurs of the sport.

Whether one decides to directly work their hip flexors (with resistance) for the sake of visual presentation, is an individual choice. But, for the average fitness enthusiast, simple stair climbing or ***Alternating High Step Ups*** is all that’s necessary.

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The Ideal Movement for the Hip Flexors

If the goal is to maximize development of the hip flexors - either for the sake of **visual presentation**, or to increase their strength for a particular sport that requires this action - an exercise that is a little more demanding that "stepping" will have to be used.

I would discourage doing any exercise that requires BOTH raising both legs simultaneously. Although these DO work the hip flexors (ironically - MORE than they work the Abs), they also strain the lower back quite a bit, and compromise the focus on the hip flexor of each individual side. Lying Leg Raises (shown below) are the most stressful on the lower back, because of the Mechanical Disadvantage that is present at the beginning of the movement.

In the photo above-left, we can see that that dreaded combination occurs at the beginning of the range of motion: the Operating Lever at its most "active" position (i.e., perpendicular with gravity), and the Hip Flexors pulling on the femurs from a mostly parallel angle. By the time the legs have entered Mechanical Advantage (photo above-right), the Operating Levers have become mostly "inactive" levers (i.e., parallel with gravity). This, combined with using BOTH legs simultaneously, really stresses the Lower Back. *Single Leg Raise* from this position is better, but still not great.

The best exercise if probably the one shown below. It allows the use of only one leg at time, it provides a place to hold on for stability, and it allows one to select the exact weight that feels appropriate. Also, since the roller is placed just above the knee (at the distal end of the humerus), there is no concern about the **lower leg** acting as a "secondary lever" - as would be the case if an ankle were used.

When working the Hip Flexors, it's best to use a bent knee, rather than a straight leg. You'll find that it's much harder to raise a straight leg - as compared with raising a leg with a bent knee. This is not only due to the fact that the straight leg is a longer lever, and therefore "heavier". Even if you added a heavy ankle weight to the bent knee version (which is recommended), the movement would still feel stronger. It allows the femur to be raised higher, and it allows one to maintaining better spinal posture. You can see (in the photo below-left) how the back becomes rounded, when one tries to raise his/her leg with a straight knee.

Using a **straight leg** - for Hip Flexor exercise - presents three mechanical impediments.

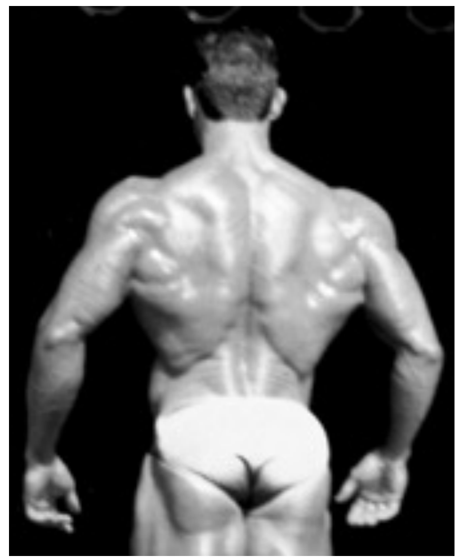
1. When a leg is raised while straight, the Hamstring of that leg stretches progressively more, as the femur is moved farther forward and upward. This results in “reciprocal innervation” - the competing activation of the opposing muscle. This seems to send a “relaxing synapse” to all the muscles on the front of the thigh.

2. Lack of sufficient Hamstrings flexibility limits the degree of Hip Flexion. It forces the humerus to stop its forward / upward movement when the Hamstring reach their flexibility limit, which prevents the Hip Flexors from reaching their full potential range of motion.

3. Raising a leg with a straight knee excessively shortens the Rectus femoris, thereby causing “overlapping actin filaments” we talk about in the Chapter 4. As the muscle becomes increasingly shorter, it becomes weaker. You can try this as an experiment, in fact. Try raising your leg with the knee straight, while standing. You’ll discover that the Rectus femoris (part of your Quadriceps) begins CRAMPING. This does not happen if the leg is raised with the knee bent - even if using an ankle weight to compensate for the resistance difference.

Chapter Twenty-Four

Calves, Abs & Lower Back

As we approach the end of the anatomy section, moving past the larger muscle groups, we arrive at the muscles which some people call “details” of the prepared physique.

“It’s easy to build big Pecs, wide Lats, and broad shoulders” - they say. “What’s hard is carving in the details of the Calves, Abs and Lower Back.”

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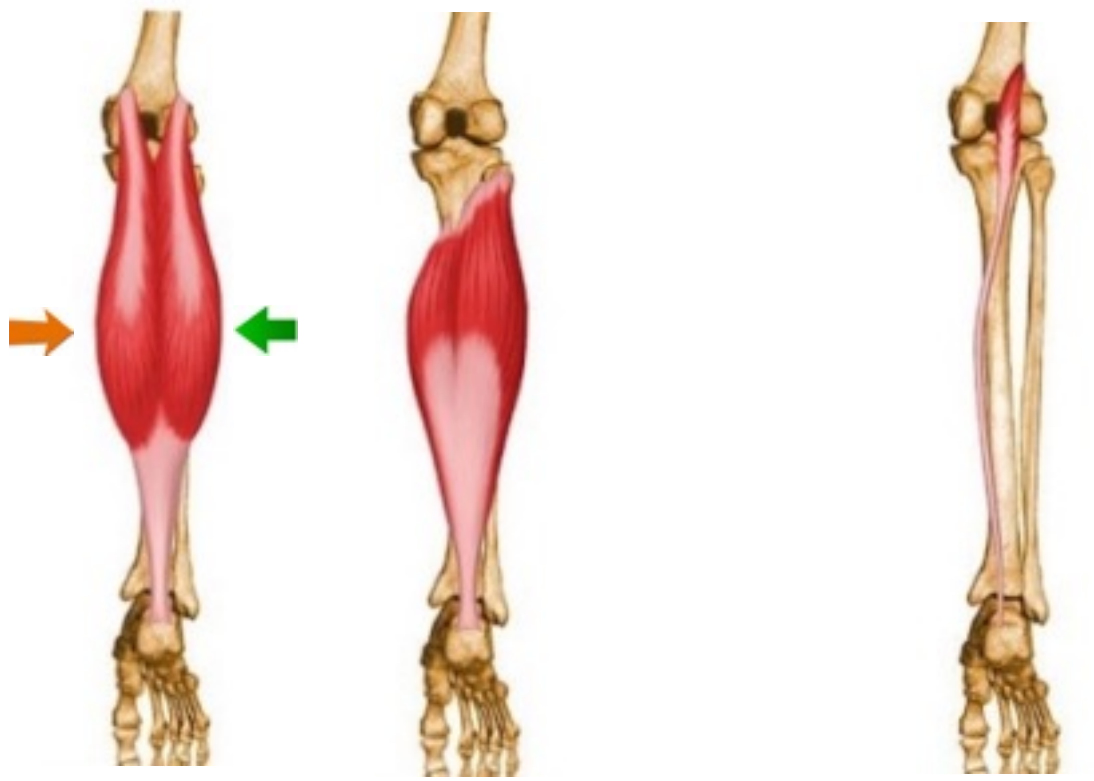
Calves

Technically speaking, the “Calves” are comprised of two separate muscles, although some anatomists consider it “one muscle”. Like the Triceps, the Calves have three origins, but only one insertion.

Aesthetically speaking, the Calves should show development when viewed from the back, side and front. Functionally, they extend the forefoot downward, thereby elevating the heel. This is known as “plantar flexion”.

In the illustrations below, we can see the anatomy of the Calves from the back and from the side. The **Soleus** lies <u>underneath</u> the **Gastrocnemius** muscle, so it cannot be seen, even when one is very lean. Also, the Soleus is a flat muscle, with essentially no capacity for growth. When our Calves grow, it's due mostly - if not exclusively - to hypertrophy of the Gastrocnemius.

In the more detailed illustrations below, we see a posterior view of the RIGHT LOWER LEG. The **Gastrocnemius** is on the far left, and the Soleus is in the middle. The Gastrocnemius is made up of two "heads". The inner "head" (orange arrow below)) is known as the *Medial head*; the outer "head" (green arrow below) is known as the *Lateral head*. The Medial head originates on the Medial condyle of the femur, and the Lateral head originates on the Lateral condyle of the femur.



The **Soleus** (above-middle) originates just below the knee. It is one continuous origin, but it spans both the Tibia the Fibula (the two lower leg bones), just under the knee joint.

The Gastrocnenius and the Soleus then **converge into a single tendon**, commonly known as the **Achilles tendon** - technically called the "Calcaneal tendon" - and connects to the heel bone (aka the "Calcaneus").

So, although the Calves appear to be comprised of two muscles, they only have one insertion, and that participate simultaneously in one primary function - extension of the ankle / plantar flexion. Therefore, it's impossible to isolate the "outer head" or the "inner head" of the Calf muscle - or even the Soleus, versus the Gastrocnemius.

The illustration on the far right (above) shows a muscle that is not commonly known (at least not in lay circles) - it is called the "**Plantaris**". Only the highest part of that long tendon is the muscle (it is only 5 to 10 centimeters long) - the rest is considered the longest tendon in the human body. It originates just above the knee (on the femur), crosses the ankle joint, and inserts onto the calcaneus (heel bone).

It participates - to a very small degree - in plantar flexion, and assists (weakly) in locking the knee. Some anatomists believe it may provide proprioceptive feedback (acts as a sensor / coordinator) to the central nervous system, regarding the position of the foot.

Interestingly, 8 to 12% of modern day humans do **not** have a Plantaris - leading some experts to speculate that it may be a remnant from our early primate days, when “grasping” with our feet was necessary.

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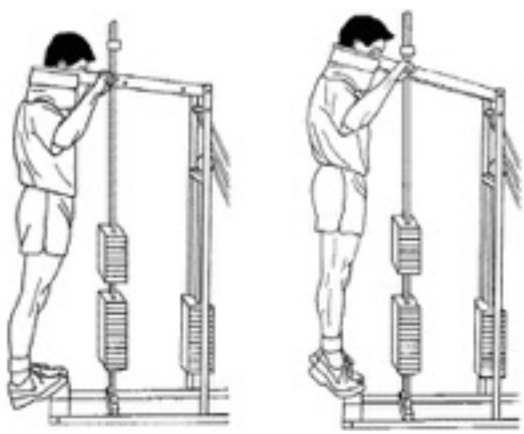
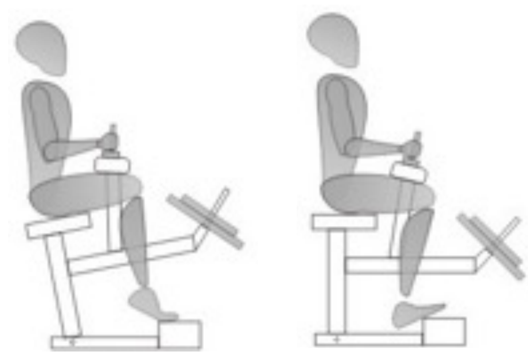
Myth Related to Calf Exercise

Gym lore has suggested that performing STRAIGHT LEG calf exercises (i.e., like *Standing Calf Raises* / shown below-left) will work the Gastrocnemius more, while BENT KNEE calf exercises (i.e., *Seated Calf Raises* / below-right) will work the Soleus more. This belief is based on the theory that when the knee is straight, the Gastroc is more elongated (stretched) than it would be when the knee is bent.





However, this implies that a muscle which is pre-stretched (in the early phase of the repetition) is **<u>loaded</u>** more, and thus grows more. However, there is no evidence of this whatsoever. Also, if this theory were correct, we would be pre-stretching every muscle, with every exercise possible. Yet, there’s plenty of empirical evidence that doing so (with other exercises and other muscles) does **not** result in more muscle growth.

It appears, however, that what **<u>does</u>** influence whether the Gastroc or the Soleus is more activated is the SPEED, and/or the amount of load, of the activation.

The Gastrocnemius is comprised of mostly “white” (type II / fast twitch) muscle fibers, while the Soleus is comprised of mostly “red” (type I / slow twitch) muscle fibers. Therefore, the Gastroc tends to work slightly more when called upon for speed, or during high-load / high-fatigue efforts. Examples of this would be running or resistance exercise. The Soleus tends to work slightly more when called upon for low-speed or low-load / low-fatigue efforts. Examples of this would be walking or simply standing.

Apparently, this is not simply theorized. The pathway for this preferential activation (Gastrocnemius versus Soleus) has been researched, and is explained in the following passage, from Wikipedia.

“The plan to use the gastrocnemius in running, jumping, knee and plantar flexing is created in the pre-central gyrus in the cerebrum of the brain. Once a plan is produced, the signal is sent to and down an upper motor neuron. The signal is passed through the internal capsule and decussates in the medulla oblongata - specifically in the lateral cortico-spinal track. The signal continues down through the anterior horn of the spinal cord where the upper motor neuron synapses with the lower motor neuron. Signal propagation continues down the anterior rami (Lumbar 4-5 and Sacral 1-5) of the sacral plexus. The sciatic nerve branches off of the sacral plexus in which the tibial and common fibular nerves are wrapped in one sheath. The tibial nerve eventually separates from the sciatic nerve and innervates the gastrocnemius muscle. Thus, completing the plan the brain had originally started, so that the actions of running, standing, and jumping could be executed.”

“Inner Calf vs Outer Calf”

Some people believe that they can preferentially activate the Medial (inner) head of the Gastroc **OR** the Lateral (outer) head of the Gastroc, simply by pointing their toes IN or OUT, during a Calf exercise. This is physiologically impossible, given the anatomy of the Calf muscle.

For example, if it were possible to preferentially activate the Medial (inner) head of the Gatroc, it would theoretically require that the Lateral (outer) head, as well as the Soleus, both **relax** - thereby **allowing** the Medial head to pull the heel bone toward the inside - rather than straight up. This is impossible because the Soleus and Lateral head would not “cooperate” that way, and because the ankle is not designed to bend that way.

Also, turning the toes in or out requires **rotation of the femur** at the level of the hip. It’s impossible to rotate the foot without rotating the lower leg, and it’s impossible to rotate the lower leg without rotating the femur. Therefore, the orientation of the Calf muscle, relative to the ankle and Achilles tendon, would still be the same - regardless of whether the toes are pointing inward or outward.

Everyone’s Calves are shaped differently, as determined by genetics. This includes whether they sweep all the way down to the ankle, or are very high - creating the appearance of a narrow lower leg. We have no control over the shape of our Calves, other than increasing and decreasing their size.

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Best Foot Position

Since the position of the foot during a calf exercise does **not** influence the shape the calf develops, we are left with the question of what might be the ideal foot position for comfort and effectiveness.

Very often, I see people in the gym, doing their calf exercises with only their TOES on the block. This would be like trying to do an upper body exercise, holding the handle ONLY by one’s finger tips. The wisest approach would be get the **most secure grip** possible, so that there is no “weak link” in the chain.

The “**ball**” of the foot refers to the large, bony pad which is behind the “big toe”. That is the podiatric equivalent of our hand’s first knuckle - otherwise known as the “Sesamoid” bones (illustration below). That entire part of our foot should be on the block because it is much more solid that are the toes. That is the part of the foot from which we can best push resistance.

Looking at the illustration of the foot below, you’ll notice that the Sesamoid bones do not form a perfect horizontal line across a vertical foot. They line up diagonally - along that red line I’ve placed there. So, in order to place all of our Sesamoid bones on the block - while the rest of our foot is OFF the block - we would angle our heels outward. This would give us the most secure grip on the pedestal.

In the illustration below, I've angled a pair of feet this way - as if they were on a Calf block, seen from below. I feel this provides the most secure, and most comfortable, footing on the block, during any given Calf exercise. Of course, this assumes one is able to turn their feet this way comfortably. Either way, the goal should be to have the most **<u>solid</u>** footing on the block. It is not wise to allow the toes to fatigue before the Calf muscle is thoroughly fatigued.

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Range of Motion

The most common error I see in the gym, in terms of Calf exercise, is people using a range of motion that is FAR to short. They usually fail to bring their heels low enough, or they fail to fully extend the foot for a full Calf contraction. Of course, this usually happens because people try to use **too much weight**.

It is foolish to do a Calf exercise, where the range of motion only travels an inch or two of distance - failing to elongate the Calf, and failing to contract it. We've all seen this, and I suspect many of those reading this right now, are guilty of it. It is very common, and very unproductive.

The **reason** we stand on a Calf block is so that we can allow our heels to drop lower than the balls of our feet. Yet - more often than not - people do not even allow their heels to drop to the same level of the block. This defeats the purpose. A muscle will not develop well using a range of motion that only represents 10% to 20% of it's full range of motion - regardless of how much weight is being used.

Use less weight, and use a **full range of motion** - heels all the way down, and then heels all the way up. Feel the Calf **stretch** on <u>every</u> repetition, and feel the **full contraction** on <u>every</u> repetition.

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Proper Resistance

In order to build a muscle, we must **challenge** the muscle - of course. Doing so requires that "substantial" weight to be used in our exercises (except when doing "high rep" sets). But, "substantial resistance" does not mean using as much weight as possible, nor at the expense of good form.

Everyone's "substantial weight" (for a given exercise) will be different, based on one's age, current physical condition, natural ability, etc. It is a MISTAKE to pick a weight on the basis of what someone else uses. The weight a person chooses for a given exercise should be selected based on the following:

1. Proper form / NO momentum
2. Full range of motion (full stretch / full contraction)
3. Deliberateness of movement (controlling the speed of the reps)
4. Appropriate for the number of reps
5. Challenging, but not necessarily requiring 100% maximum effort
   (90% to 95% is usually sufficient)

Often times, people consider the “weight stack” on a Standing Calf Machine, as a challenge. They make it their goal to use the entire stack. This is absolutely foolish. The amount of weight that is on a machine **has not been calculated using actual testing** of people performing that exercise with strict form. It is simply an amount of weight that will make the most number of people “happy”, commercially speaking. That includes people who choose to use a very partial range of motion.

If you are truly honest with yourself, and you use the 5 criteria mentioned above, you will likely discover that the Calves can be worked **very well**, using only a third of the weight that is typically available on a weight stack - often less.

Consider this: a ***Bodyweight*** *Calf Raise* for a 180 pound bodybuilder is already loading EACH Calf muscle with well over 450 pounds.

(180 pounds divided by 2 legs = 90 x the magnification provided by the length of the foot lever… a factor of 5, most likely)

A “***<u>One Legged</u>*** *Bodyweight Calf Raise*” would likely load each Calf muscle with over 900 pounds - without using any **additional** weight.

Often times, I find that “bodyweight” is already too much for a warm-up set, because I use a full range of motion, with deliberate stretch and contraction on each repetition. What’s needed - in terms of gym equipment - is NOT a machine that has a **heavier** weight stack. What’s needed is a machine that allows a person to use LESS than their full bodyweight - at least for their warm up / higher rep sets.

I find it very practical to use a type of Leg Press (below), where we can use less than our own bodyweight (e.g., 80 or 100 pounds) for our warm-up set, and then increase the resistance from there. Some people might only need to use 50 pounds (using both legs) - and that's perfectly acceptable. It is foolish for us to assume that we "must" use the heaviest weight possible for Calf exercises, or to be influenced by what others use, or to be "challenged" by the amount of weight found on the average Standing Calf Machine. We should allow the "feeling" of the exercise to help us determine how much to use weight to use, while doing the repetitions **properly**.

Generally speaking, I like starting on the *Seated Calf Machine*, because it's easy to use a lighter warm-up weight on that, as compared to using my full bodyweight from a Standing position. After four or five sets - increasing the weight on each subsequent set - I moved to a Standing Calf Machine, or to a Leg Press machine (for Calf extensions). But I'll rarely use more than a **total** of 300 pounds during a set, and that includes my 200 pounds of bodyweight (i.e., 100 pounds on the Standing Calf Machine).

It’s foolish to be influenced by the fact that the Standing Calf Machine typically has 300 or 400 pounds available. It’s entirely irrelevant. We should not perceive that as an indication of how much weight we “should” be using - even if we saw someone else using it. Almost no one can manage using that much weight, while using proper form. If they can, that’s fine. But if the form is compromised, than it’s a mistake to use that much weight.

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Abs

Specifically, this section is about the **Rectus Abdominis** - which is sometimes referred to as “the six pack”, or just “Abs”.

The Abs may be the most misunderstood of all the muscles of the body, and yet - ironically - the simplest to develop. This is one of the greatest ironies in the fitness industry.

The anatomy of the **Rectus Abdominis** is even more “simple” than that of the Biceps. Most everyone knows that to develop their Biceps, they should do “curls” of some kind.

Most everyone knows that “curls” require bending the elbow. The Biceps muscle crosses two joints, and has two parts (“heads”), while the Abs only crosses ONE joint and has only one “head”. The Abs is actually a much simpler muscle, by comparison - and STILL, more FAR mistakes are made when attempting to develop the Abs.

To be fair, this confusion is not the fault of the consumer. After all, most people follow the advice of magazines, which is almost **always** misleading. But even trainers get it wrong, due to the over-commercialization of fitness industry. They’ve been lead to believe that it’s better to have 20 mediocre ways of training the Abs, than one BEST way.

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The Most Common Misunderstanding Related to Working the Abs

Before we get into the anatomy of the Rectus abdominis, let’s address one of the biggest myths of getting great Abs. **Abdominal exercise will NOT diminish the fat that is on one’s midsection**.

The **Number One** reason people do “Ab exercises” is to reduce the fat in that area - and yet, reducing that fat is **least likely to happen** when doing Ab exercises.

Most people have heard that “spot reduction” is a myth, and yet they still do Ab exercises believing (or hoping) that their midsection will become less fat by doing so. Maybe this is because of the erroneous marketing they’ve seen, or because people naturally seek a “short-cut” whenever possible, or because no one has ever explained to them how the process works.

Here’s how the process works:

When we are eating more calories than we are spending, we store the “extra” calories as body fat. That body fat is distributed all over our body - but more in some areas, and less in other areas. This distribution is determined by our genetics.

We cannot choose where (on our body) to accumulate fat, and we cannot choose from where we’d like to remove it. All we can do is put our body into “fat loss” mode (by eating less and exercising more), and allow the fat-loss process to occur in the reverse order in which it came on.

When we perform Abdominal exercise, we are doing two things: strengthening the muscle and spending calories.

If that calorie spending exceeds our calorie intake, we may lose a little bit of fat - but it will only be from the whole body. That is the way the body handles a

“calorie deficit”. It uses (spends) its fat reserves - in tiny amounts, from the whole body - when it needs it.

However, the calorie demand of an Abdominal Exercise is much less than the calorie demand of Squats or Rowing or Stationary Bike. That is why one is less likely to lose body fat while doing Ab exercises, than they are by doing exercises that are more demanding (i.e., increase heart rate and respiration).

The reason why we cannot burn body fat that is closest to the working muscle, is because body fat is not use-able fuel. Body fat (“adipose tissue”) must first be converted to a use-able fuel (“free fatty acids”) before it can be spent / burned. That conversion does not happen in only one area - and certainly not in the area that is closest to the working muscle. That conversion happens systemically - throughout the entire body (in tiny amounts) - when it happens at all.

This is why we lose fat from our face and arms, when we are pedaling a Stationary Bike - even though it is our legs that are doing the work. If we are in a calorie deficit - demanding more calories in energy than we have consumed - our body releases body fat in the reverse order than it came on - regardless of which muscles are being exercised. However, generally speaking, exercise that involves the legs is usually the most demanding - requiring the most fuel.

So, one is more likely to burn fat off of their midsection by either working their Leg muscles, or doing cardio exercise, than they are by doing Abdominal exercise.

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Body fat cannot be made “firm”, and it cannot be converted to muscle. Abdominal fat (along with the fat on other areas of the body) must be “burned” as part of a **calorie deficit**, which involves total body exercise and a reduction of one’s calorie intake.

Of course, this does not mean that a person should NOT exercise their Abs. But it does mean that we should consider Ab Exercises the same way we consider Biceps or Pectorals Exercises. We are working the muscle - not “losing” the fat.

We would not train our Biceps and Pecs every day; we should not train our Abs every day.

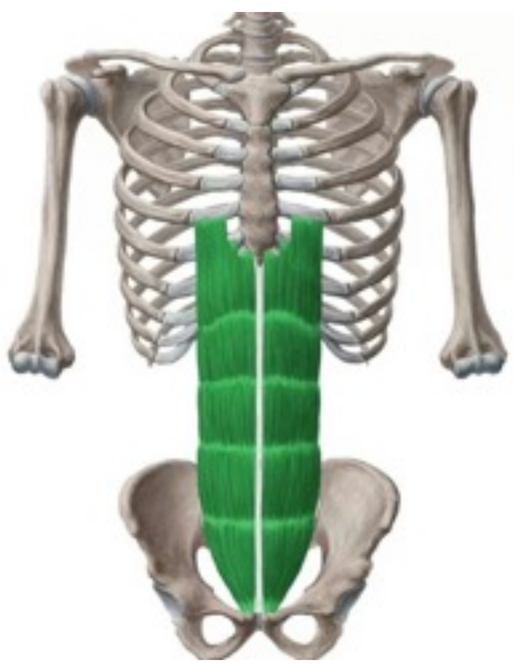
We should **not** do 100 repetitions per set for Abs. We would not do 100 repetitions for Biceps or Pecs.

We should use “full range of motion” when working our Abs, because we use **full range of motion** when working the Biceps or the Pecs. We would **<u>not</u>** use “static” (isometric) exercise when working our Biceps or Pecs - so would we assume that doing Planks (which is isometric) is good for working our Abs?

Localized fat loss is physiologically impossible - despite marketing efforts by people (magazines) trying to sell us that fantasy. We must be aware that those marketing efforts are deceptive and inaccurate. We must not believe marketers (advertisers) when they tell us that using their product will help us “trim” our midsection, or “lose the belly fat”. It is a lie. It is physiologically impossible. If we “buy” those misguided recommendations, we waste time, energy and money - and we encourage those marketers to continue the deception.

Let us now examine the anatomy of the Abs. In the illustrations below, we can see the general anatomy of the Rectus Abdominis.

This muscle originates on the front of the ribs (the costal cartilage of the 5th, 6th and 7th ribs, and the Xiphoid process), and inserts onto the Pubic Bone (“crest of the pubis”) of the Pelvis. When the muscle contracts (shortens), it pulls the origin and the insertion closer together, thereby producing “spinal flexion” - a forward curving of the spine. This is a very straight-forward function.

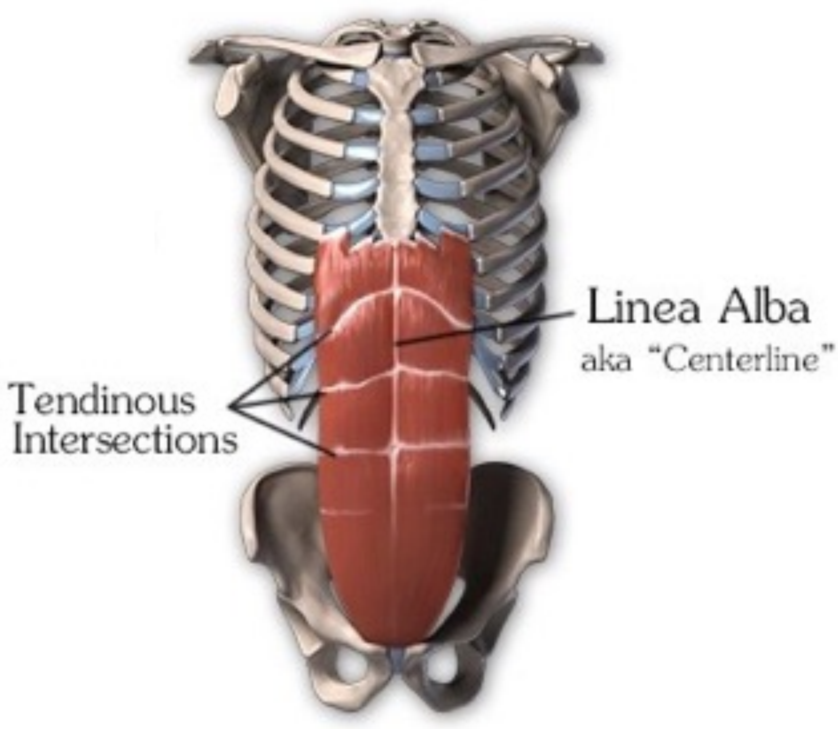


There is only one muscle - not two. There is no separate “upper abs” and “lower abs”. There is only **one origin**, **one insertion** and **one primary function**.

Do you see those “dividers” in the muscle sheath - the divider that runs down the center, and the ones that run horizontal to the muscle? Those have been there since the day we were born. The configuration of these shapes, as well as the number of “notches” we have, are determined by our genetics.

We cannot add any additional dividers. This means that we cannot convert a “four pack” into a “six pack” - no matter how hard we try. We can only build what we have, and make what we have more visible, by lowering our body fat level.

In the illustration below, we see that the divider that runs down the middle is called the “Linea Alba”, and the horizontal dividers are called “Tendinous Intersections”. They are, essentially, **tendons**. We can no more add another “**abdominal** tendon”, then we can add another Achilles tendon. It is IMPOSSIBLE. Therefore, it is futile to try to add another “row” of abs in the “lower region”.



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Leg Raises for “Lower Abs” ?

Of course (and again), there is no “Lower Abs”. As we learned in Chapter 11 (“The All or Nothing Principle of Muscle Contraction”), a muscle either contracts from origin to insertion, or it does not contract at all. When a muscle contracts, the tension in that muscle is evenly distributed throughout the entire length of that muscle.

Yet, there are literally **<u>millions</u>** of online references suggesting that Leg Raises will develop the Lower Abs. Often, this falsehood is told to us by people we expect to tell us the truth ! But it is NOT true. It is false. It is impossible.

If it were possible to cause one end of the muscle to contract more than the other end, it would defeat “God’s / Mother Nature’s” purpose for muscle contraction - which is to produce skeletal movement by bringing the two ends together. The two ends cannot come together, if there is “slack” somewhere in the “rope” (the muscle).

Also, as we learned in the **Hip Flexor** section, the “***Leg Raise***” motion is produced exclusively by way of the Iliopsoas, Rectus femoris, Sartorius and Tensor Fascia Lata - NOT by the abdominals. Yet, people do Leg Raises with the idea that they’re “working” the Lower Abs.”

Any tension in the Ab muscle, while doing Leg Raises, is only for the purpose of maintaining rigidity of the spine, while the Hip Flexors do the “dynamic” work. Further, whatever abdominal tension there is during *Leg Raises*, is **evenly distributed from origin to insertion** (from top to bottom). It is NOT localized in the lower region of the muscle. It cannot be.

So, if we know that we **cannot spot reduce** the fat that is on the lower region of the midsection, and we know that we **cannot add any more Tendinous Intersections** (“lower ridges”) to our Abs - what would be the purpose of trying to target the Lower Abs? **Nothing can change anyway.**

The Ideal Anatomical Motion for the Rectus Abdominis

Following our usual guideline for determining the “ideal anatomical motion” for a target muscle, we ask: “What is the ideal action of the Rectus Abdominis?”. The answer is: “The Rectus Abdominis <u>forward flexes the spine</u>.”

The most common exercise demonstrating this action is the “abdominal crunch”, which is typically performed on a floor mat (below).

This “action” is theoretically correct, although the direction of resistance (relative to the torso) is NOT ideal. This is because the weight of our torso is generally more than the Abs can handle, which often causes the movement to be incomplete. The vast majority of people cannot curl their torso into a full abdominal contraction, from this angle. But we will address the “ideal” direction of resistance in a moment.

The “ideal” anatomical motion for the Rectus abdominis is forward flexion of the spine - moving the base of the Ribs directly toward the pubic bone of the pelvis.

“Reverse Crunch” ?

The idea of trying to bring the Pelvis toward the Ribs, instead of bringing the Ribs toward the Pelvis, is foolish. The muscle does not “know” which end is coming toward which end. The only thing the Ab muscle “knows” is that it is shortening (contracting), and that the two ends are coming together. Either way, the result is the same - as far as the muscle is concerned.

The most sensible strategy - when working the Rectus Abdominis - is to anchor the part that is easiest to anchor (the lower body / hips / legs), and bring the Ribs toward the lower body. It’s MUCH more difficult and cumbersome, attempting to anchor the upper body / Ribs, and then bringing the Pelvis up toward the Ribs. Plus, there is NO advantage in doing so.

Ideal Range of Motion

There are two issues which need to be acknowledged, when considering the Range of Motion of an exercise: 1) How much muscle elongation and contraction is “enough” or “ideal”, and 2) What is the safest movement for the joint(s).

In all cases, we should ask ourselves this two-part question:

1) What is best for the muscle?
2) What is best for the joint(s) involved?

When we’re dealing with the spine, it becomes even more important.

The generally accepted “safe” ranges of spinal movement are as follows:

40 to 60 degrees of flexion (forward bending)

This would be “active” flexing, where the spinal bending is produced by the abdominal contraction. 40 to 60 degrees of “passive” flexing may NOT be safe. This would be where the spine is being pushed (forced) into this degree of flexion, by a source OTHER than its own muscle contraction. An example of this would be doing a *Bent Over Barbell*

Row or a *Dead Lift*, with 50 degrees of flexion in the spine, **produced by the barbell pulling** the torso forward.

20 to 35 degrees of extension (backward bending)

The same stipulation as above, holds true here as well. This degree of extension is acceptable as “active” extension, but it is not necessarily acceptable as “forced” extension.

(Note: There are also parameters for Lateral flexion (sideways bending) and Rotation, and they will be addressed later when we discuss “Internal / External Obliques” and “Transverse Abdominis”.)

Clearly, we can twice as much forward flexion mobility, than backward extension mobility - from the perspective of spinal safety. However, in my experience, I have found that going past the “straight spine” position (during extension / eccentric phase of the range of motion) does **not** provide any advantage, in terms of Abdominal development. Going beyond the “straight spine” position is also less comfortable. So, I recommend excluding that part of the range of motion.

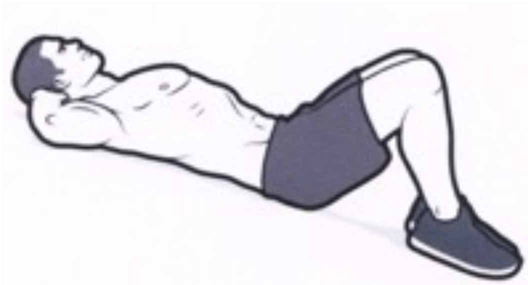
Abdominal contraction (forward flexion) can be taken as far forward as the Rectus Abdominis will cause, with perfect spinal safety. However, more often than not, people FAIL to complete the forward flexion to full abdominal contraction. People often seem more concerned with “whipping out” a specified number of repetitions, without much regard for the **quality** of those repetitions. This usually leads to a very short (insufficient) range of motion, and a lack of muscle contraction.

Complete forward flexion of the spine and deliberate contraction of the Rectus abdominis, is much more likely to produce muscular development of the Abs, as compared with a partial range of motion and avoidance of Abdominal muscle contraction.

The Ideal Direction of Resistance

Under normal circumstances, I would suggest that the **direction of resistance** be perpendicular from the operating lever of the target muscle, when it is at the beginning of its range of motion. I still recommend that, provided we have control over the amount of weight / resistance we will be using. However, when we’re dealing with body weight as the resistance source, a perpendicular angle (relative to the operating lever) provides too much resistance.

So, if one does not have access to an adjustable pulley and a upright bench, then the amount of resistance can be manipulated, even though one is dealing with body weight. In the illustration below, we see how using an incline bench can create a “less active” starting position, and lessen the amount of resistance that is loaded onto the Abs.



However, if one DOES have access to an adjustable pulley and an upright bench, the ideal direction of resistance is one that utilizes a cable, set mostly perpendicular to the torso, when the torso is at the starting position of an Abdominal Crunch motion.

If this angle of incline does not relieve the resistance enough, a higher incline angle can be used. The important thing is to use enough resistance to challenge the muscle, but not so much as to limit the range of motion.

This type of Incline angle can be achieved by way of a massage table (with adjustable legs, of course), or an adjustable Incline Bench, or even a simple board that is propped up against a step or ottoman (on the floor).

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In the photos above, you can see that I'm performing an *Abdominal Crunch* motion, but from a sitting position - rather than a lying position. I can do this, is because I have now replaced "free-weight-gravity" as the source of resistance, with a Cable resistance that is set perpendicularly from my torso.

In the photos below, I am using a pulley that is set at a slightly higher level. This changes the resistance curve a bit. It's not necessarily better nor worse. Both are good. I encourage people to experiment and find the angle that feels best for them. However, from a mechanical prospective, using a higher pulley reduces the resistance at the beginning of the range of motion, and increases it toward the end of the range of motion.

Keep in mind, however, that this exercise also deals with the issue of a "Secondary Resistance" source, which we discussed in Chapter 6. The farther we forward flex our torso (while seated), the more that our own torso weight "falls" forward (if it were not being pulled up and back by the cable). So, our torso weight has to be off-set by the opposing cable resistance.

For this reason, it's not a bad idea to have the pulley set a bit higher, thereby providing a slightly "upward" pulling direction that counter-balances the weight of our torso "falling" forward.

However, either of these two cable heights are good. Using a cable for resistance - as opposed to using body weight - provides us with the advantage of being able to select the exact amount of resistance that allows us to challenge the Abs, but not so much that it prevents us from fulling contracting and performing a full forward flexion. It also allows us some freedom in terms of the angle from which it pulls - which gives us more control over the resistance curve than we'd have when using our body weight as resistance.

These two exercises - ***Seated Cable Ab Crunch*** and ***Incline Bench Ab Crunches*** are absolutely the 1st best and 2nd best (respectively) Ab Exercises, in my opinion.

The rest of the Ab Exercises we often see in the gym are **far behind** these two, in terms of anatomical motion and resistance curve.

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These include the following:

* **Knee Tucks**: Dynamic work done almost entirely by the Hip Flexors. Abdominals working only isometrically.

* **Planks**: Completely isometric. No Rectus Abdominis elongation or contraction. If isometric exercise were “productive” (for muscular development), we would be using it on ALL of our other exercises, for all our muscle groups. The reason we don’t, is because it is NOT as productive as dynamic exercise.

The criteria for what qualifies as a “good” resistance exercise includes “dynamic movement” and full (or mostly full) range of motion. The Rectus abdominis is a muscle, like any other skeletal muscle.

*   **Leg Raises**: All *Leg Raise* exercises (“Lying”, “Hanging”, etc.) - intended for the purpose of developing the Abdominal muscle - are ridiculously inefficient. They are mostly (70% to 90%) Hip Flexor work.

*   **Knee Tucks while on a Swiss Ball**: These are as unproductive for the Abs, as the Knee Tucks on the bench (above), with the difference being that this involves much more Quadriceps fatigue. In other words, the energy cost is greater with this exercise, but the reward to the Abs is not greater. Is this beneficial for the Quadriceps? Yes, but arguably not as good as Cable Squats or Leg Extensions. If one does **not** want “optimal results”, than this is good enough for Quadriceps stimulation. But if one wants optimal results, another Quad exercise would still need to be done.

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To be clear, this does not mean that these exercises above DO NOT work. They DO work, and there is plenty of evidence of that. Thousands of people have developed reasonably good Abs using these exercises. However, the cost / benefit ratio is not nearly as good. These exercises require more time and effort, and provide less reward.

If we could measure the amount of time and effort that has been by spent to produce a “beautiful six pack” (ripped abs) by **people who have used “inefficient” exercises** (like the ones above), as compared with the amount of time and effort I’ve spent to develop my abs, it would a dramatic difference.

My investment is one abdominal exercise, 5 to 6 sets per workout (20 to 30 reps per set), performed once every fifth or sixth day. And I get the result shown below*.

*(Note: * The condition below still required a strict diet, of course. However, it did not require more abdominal exercise than that which I just described.)*

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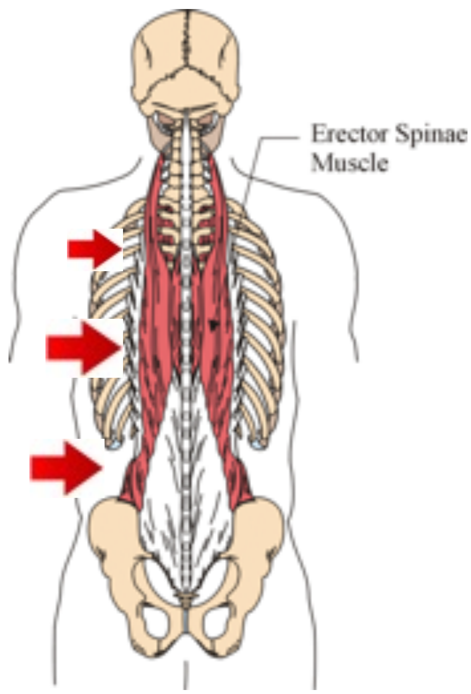
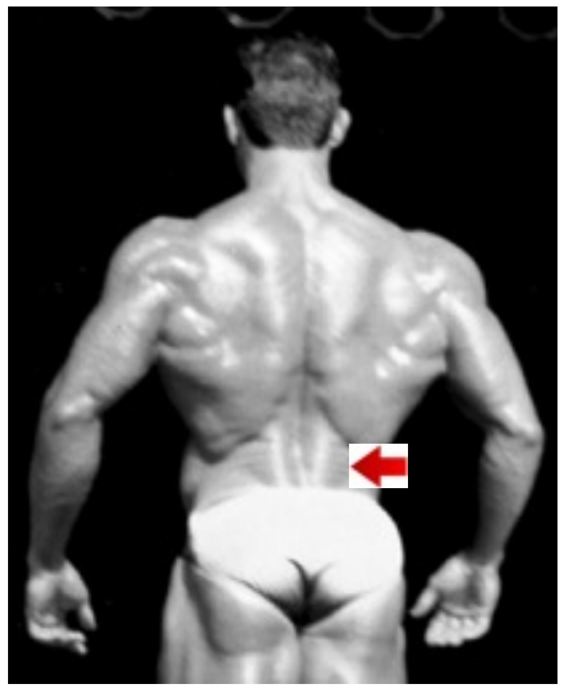
The "Lower Back"

The idea that the "Lower Back" is a muscle, is incorrect. The area of **Erector Spinae** which is visible on the Lower Back, is really only a small portion of the group of muscles that stretch from the rear of the Pelvis, all the way up to the top of the spine. In the illustration below-**left**, you can see the entire length of these muscles. In the photo below-**right**, you can see how only the bottom portion is visible.



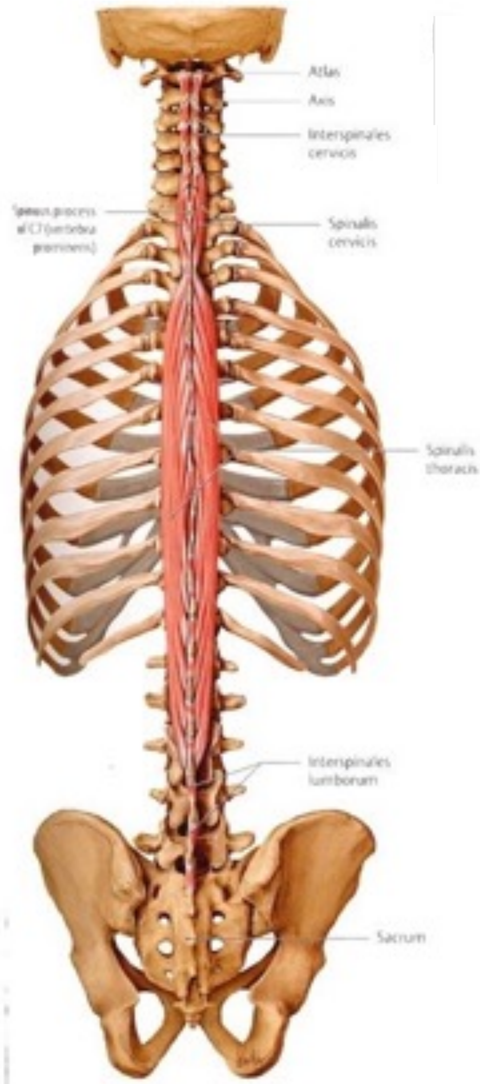


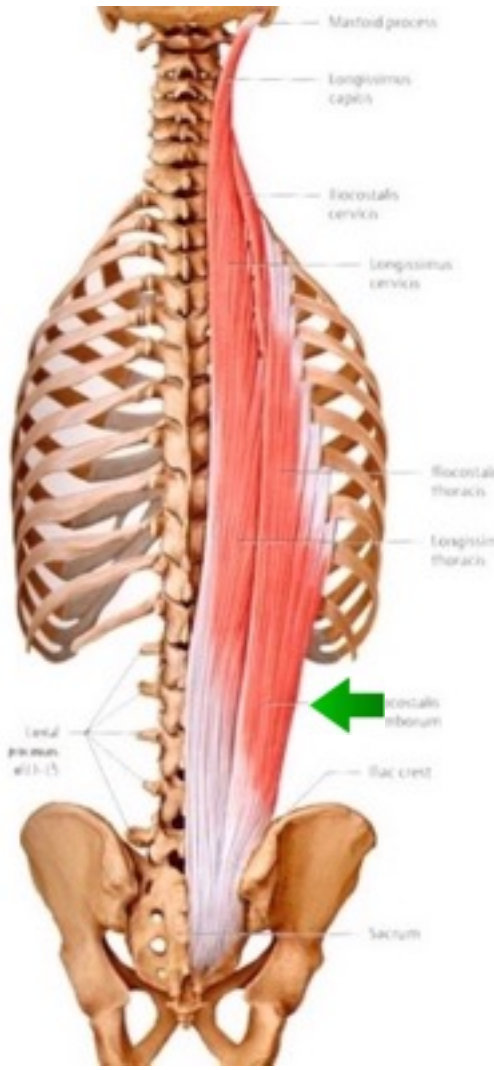
When we look at a muscular back, we see the "superficial" muscles - the Latissimus, the Trapezius, Teres major, etc. The **Erector Spinae** are almost entirely <u>beneath</u> these muscles. The only part that is actually visible, is the lowest portion - because there is no other muscle covering it. There is no separate "Lower Back" muscle,….just like there is no separate "Lower Abs" muscle.

This group of muscles **originates** on the back/upper portion of the pelvis, sacrum and lumbar spine. As it rises, it splits into three separate columns:

1. the "Spinalis" (closet to the spine / seen on the figure below-left),
2. the "Longissimus" (next column, lateral from the spine / seen below-right), and
3. the "Iliocostalis" (farthest column, lateral from the spine / also below-right).

Then, these three columns attach in various places on the vertebrae, ribs and even the back of the skull.





The primary function of the Erector Spinae is to “extend” the spine (to pull it back, posteriorly), or prevent the torso from being pulled forward. The most lateral of the three columns (farthest from the spine, indicated by the green arrow above) also **assists** in rotating the spine - although torso rotation is primarily caused by the Internal and External Obliques.

The part of the lower back that is often referred to as the “Christmas Tree””, is actually the outline of the lowest part of the Latissimus, as it converges with the tendinous tissue. That is NOT part of the Erector Spinae.

One of the most admired “backs” in the history of bodybuilding, is that of Samir Bannout (1983 Mr. Olympia, as well as many other titles) - shown below. Indeed, his back is extraordinary, in every regard - including the “Christmas Tree” outline of his Latissimus attachment. But let’s focus our attention on his “Lower Back”.

What is most remarkable about his back, is his level of definition - the clarity of the muscles below the skin, due to his super-low level of body fat. Of course, his back muscles are extremely well developed too. But the striations (lines) we see in his lower back area are visible because of his level of leanness. They would not be visible, if he were not this lean - regardless of whether or not the muscle was developed.

When people see these photos of Samir, they often feel motivated to work their Lower Back much harder at the gym - with Dead Lifts and “Hyperextensions” (i.e., Lower Back Extensions). There are a couple of problems with this thinking, however.

The first problem is that without this degree of clarity (low level of body fat), even the MOST well-developed back muscles would not look like this. Thousands, if not millions, of bodybuilders all over the world - who work their Erector Spinae with heavy Dead Lifts (below-left) and Hyperextensions (below-right) - never achieve this appearance in the Lower Back area. Super low body fat (leanness) is required.

The second problem relates to the question of **how much** the Erector Spinae CAN be developed, and whether or not Dead Lifts and Hyperextensions are the best way to develop this muscle group. We will answer both of these questions, shortly.

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How Much "Lower Back" Exercise Is Enough / Too Much ?

Let's assume that you are planning on working your "Lower Back" (Erector Spinae) today, and you are planning on doing the two exercises shown above. The two exercises shown above are the most commonly used for developing the lower back, but neither of them are very good for this purpose.

Both of theses exercises **mostly** involve Dynamic movement of the hip joint (i.e., "Hip Extension"), along with Isometric tension of the Erector Spinae. In other words - in both cases, the Erector Spinae are only **maintaining** rigidity in the spine (also known as "static tension"). There is very little muscle elongation and contraction occuring. In both cases, the Glutes are doing the majority of the work, because they are working Dynamically.

There is another problem occurring as well. Let's assume that the day before, you did exercises for your Lats and "Upper Back" - including *Low Cable Rowing* (below-**left**). The day before that, you did "Legs" - including Barbell Squats (below-**right**)

In both of these exercises, the Erector Spinae are ALSO working. And they were working in the exact same way - Isometrically - as they do when we do Dead Lifts and Hyperextensions.

Perhaps on one of those same workout days (or on yet another workout day), you did *Barbell Curls* for Biceps…and you *Front Barbell Raise* for Anterior Deltoids. Both of these exercises ALSO loaded the Erector Spinae isometrically. All of these exercises pull the torso forward, and require static tension by the Erector Spinae to keep the torso from folding forward.

So, we've loaded the Erector Spinae isometrically for three or four consecutive days - and yet we think that **more** isometric work for the Erector Spinae is necessary and will be productive - simply because (on that fourth or fifth day) we call it "Lower Back" exercise ?

Do you see the irony here? People refer to ***Seated Cable Rowing*** as a Latissimus / Upper Back exercise, and they refer to ***Barbell Squats*** as a Leg / Quad exercise - and **ignore** the load that is placed upon the Erector Spinae in both exercises.

They refer to ***Barbell Dead-Lifts*** and ***Hyperextensions*** as "Lower Back" exercises, even though the both exercises work the Glutes more than Erector Spinae. And yet, the Erector Spinae are doing the EXACT same thing in those two exercises, as they do in all the other exercises where the torso is pulled forward by resistance, and is required to maintain rigidity in the spine.

1. Are the Erector Spinae getting too much work already?

2. Do we need more Erector Spinae exercise?

3. Is there a better way to work the Erector Spinae that is NOT **isometric**?

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Before we discuss the “best” way to work the Erector Spinae, I’d like you to look at the six photos below. The top three photos are of young, amateur bodybuilders; the bottom three are of seasoned, professional bodybuilders. The photo in the center of the bottom row is that of Arnold Schwarzenegger; the one that is on the far right of bottom row is that of the great, Frank Zane. Focus your attention on the “lower back” area of all these athletes. You’ll notice that there is NOT much difference in that area, despite a tremendous difference in years of effort.





What this shows, is that the Erector Spinae simply do not have much capacity for growth. Of course, the Lats, middle Trapezius, Deltoids, and arms have a significant capacity for growth, and this is what makes the pros’ “Back Double Biceps” look so impressive. But it's obvious that their "lower back" area is not able to develop the same degree of visible improvement as their other muscle groups.

It's also worth noting that Arnold Schwarzenegger began his bodybuilding career as a Power Lifter. He spent a considerable amount of effort - for years - doing **heavy** *Dead Lifts*, as well as **heavy** *Barbell Squats* and **heavy** *Rowing.* See the photos below. It's safe to say that he loaded his Erector Spinae quite a lot. And yet, in the series of photos above, his "<u>lower back</u>" is not significantly more "thickly developed" (deeper) than any of the others - including the amateurs.

On the Continent it is more usual for top physiques also to be top power lifters. Here ARNOLD SCHWARZENEGGER makes a new dead lift record of 710lb!

What might be the reason for this? Consider the two illustrations below. That lower part of the Erector Spinae that is visible (not covered by the Latissimus) is mostly **tendinous** tissue - which has almost no capacity for growth. And, it seems that even the muscle fibers of the Erector Spinae cannot grow, the way Pectorals and Latissimus can.

The message here is that it's unwise for us to expect much visible development from working the Erector Spinae. And it's simply foolish to risk the future health of our spine, by performing 400 pound Dead Lifts, when the reward is almost insignificant - in terms of visible Lower Back development.

Again, the "Christmas Tree" definition we see on some bodybuilders is NOT the Erector Spinae. That part of the musculature can still be achieved - even if we don't perform any "specialized" lower back (Erector Spinae) exercises, at all.

Occasionally we see a person with an unusually deep groove between the two columns of the lower back area. This is due to genetics. Some genetically fortunate people have a very deep muscular groove down the center of their back, even if they don't do any bodybuilding type of workouts. I've seen basketball players who have that type of back "depth", despite not doing any heavy lifting, and despite the rest of the body not being so muscular. When these genetically-lucky individuals pursue bodybuilding, their Lower Back musculature becomes even more pronounced. Unfortunately, we are not all so genetically gifted.

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Our Erector Spinae will **always** get a significant amount of loading as part of the "peripheral recruitment" that occurs when we are working other muscle groups.

Any kind of ***Rowing*** exercise (that is not chest-supported) will load it, as will any kind of ***Squats***, some Deltoid exercises, and most kinds of ***Biceps Curls***. Even carrying a heavy dumbbell to a bench, or putting a 45 pound plate back on a rack, will load the Erector Spinae. Of course, this contraction of the Erector Spinae is mostly isometric, which is arguably not as good (in most cases) as dynamic contraction. But still, the amount of loading this muscle gets "peripherally" - day in and day out - is significant.

So, the one thing the Erector Spinae does NOT need is more isometric tension. It really makes no sense to do "more of the same" isometric work, after doing so much isometric work for this muscle group. If anything, what it might need is a little bit **dynamic** exercise.

Of course, working the Erector Spinae **dynamically** will still not make a huge difference in the visible development of that lower area. However, since we rarely contract this muscle group **dynamically**, it will likely improve the mobility of the spine (possibly), and will strengthen this muscle group through a broader range of motion.

In the photos below, I am performing a ***Seated Torso Extension*** exercise. You'll notice that the "pivot" is now mid-spine; it is not at the level of the hip. This is causing the Erector Spinae to elongate and contract, dynamically.

I realize this looks too “easy” - much more so than doing Dead Lifts with 200 pounds or more. But, you’d be surprised how much fatigue you’ll feel in the Erector Spinae, when you do it. There is a big difference between working a muscle dynamically, and working it isometrically.

As you can see, I am simply rounding my spine forward (photo above-left) - and then arching (extending) my back. It’s the same spinal movement that occurs during a good Rectus abdominis (Abs) exercise, but with me facing the opposite direction of resistance (gravity). During an Abs exercise, the concentric contraction is going forward - anteriorly. During this exercise, the concentric contraction is going back - posteriorly.

In these photos, I am holding a 10 pound weight, but - frankly - it’s not even necessary. Again, this exercise is very challenging, when done correctly. If you’ve mastered the motion without weight, and feel it necessary to add 10 or 20 pounds, it’s fine. But you likely will not need it.

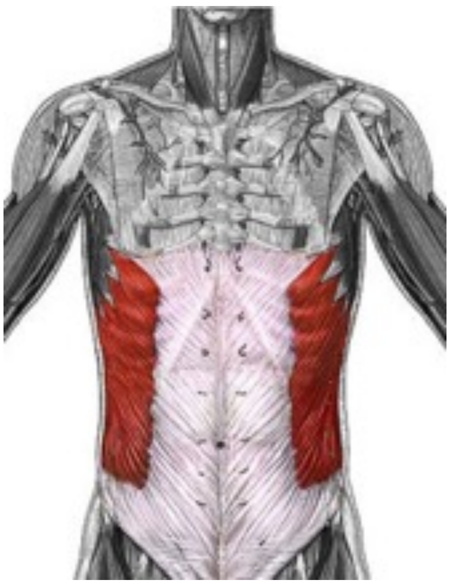
In the photos below, I am performing a different version. It’s the same motion, but with a different resistance curve. Since my torso is more perpendicular with gravity (in both, the starting position and ending position), the resistance being loaded onto the Erector Spinae is considerably more. Either of these two exercises are great.

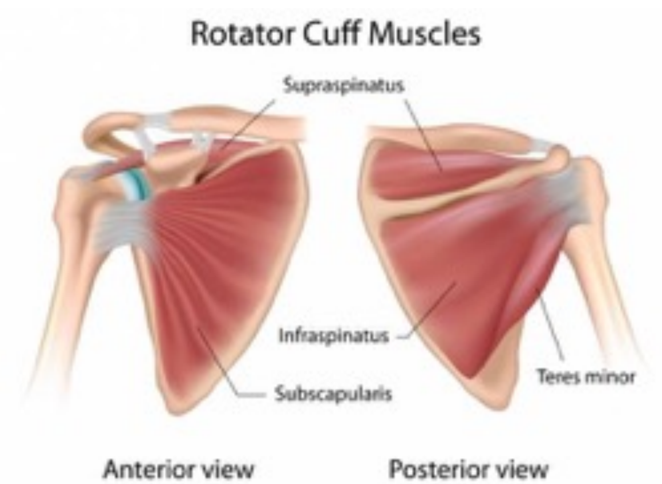
If a person performs all the "usual" bodybuilding / fitness exercises, they probably do not need any additional exercise for the Erector Spinae. It's likely their Erector Spinae is already getting more than enough exercise for functional strength, and whatever visible development is possible. They certainly don't need - and will not benefit from - more isometric exercise (like Dead-Lifts).

However, the isolated exercises above may be useful. They might make a small improvement in the visible development of that lower part of the back. However, I find that this type of exercise is very functional, and beneficial for that reason. This type of exercises "teaches" the Erector Spinae to coordinate spinal movement that is not "rigid" - in one single position. It develops strength and mobility through the entire range of motion of the Erector Spinae, as short as that may be.

Chapter Twenty-Five

Internal & External Obliques, Transverse Abdominis & Shoulder Rotators



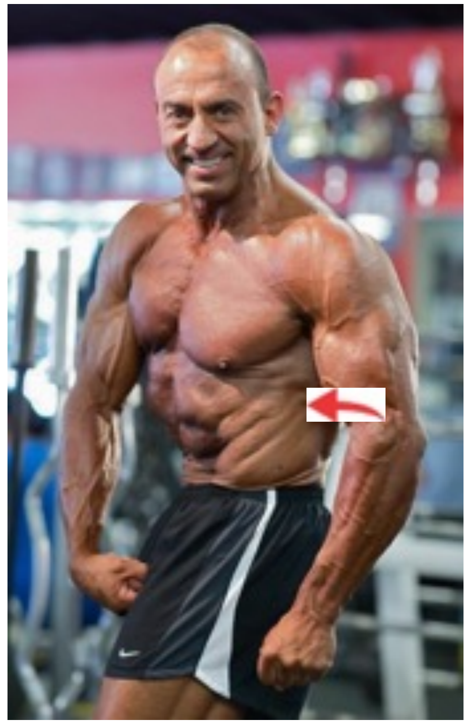


The Obliques

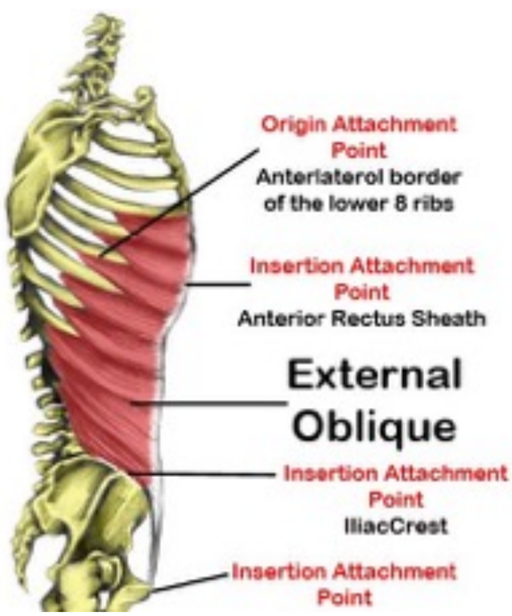
The “Internal” and “External Obliques” are two sets of muscles located on the sides of our midsection. Their primary anatomical functions are side-to-side torso flexion, as well as torso rotation.

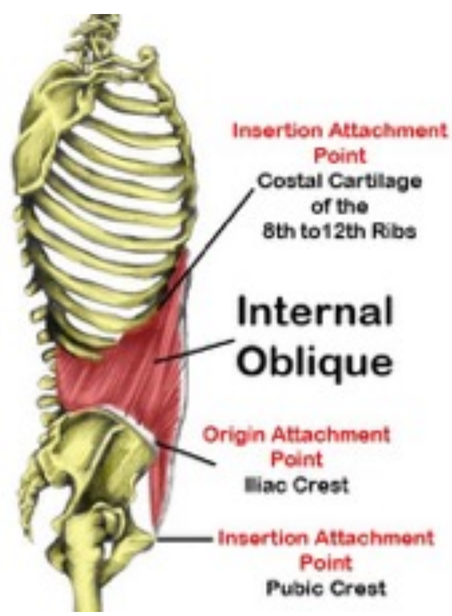
The **External Oblique** is the more superficial of the two (closer to the surface). It’s the only one whose fibers are visible, and **only** when a person is lean enough (usually below 6% body fat). The **Internal Obliques** lies **beneath** the External Obliques - too deep to be visible. These two muscles work together, simultaneously. So, if a person wanted to only exercise the muscle that is visible - and neglect the Internal Oblique - it is impossible to isolate only the External Oblique.

From a bodybuilding / physique development perspective, the External Obliques looks like fingers that extend diagonally from the Rectus abdominis. When a person is lean enough, these “lines’ are clearly visible - seen from the side or from the front.



The illustrations below allow us to see the origins and insertions of the External Obliques (below-left) and the Internal Obliques (below-right).





As you can see, they attach to the ribs, the Iliac Crest (sides of the pelvis), the Pubic bone (center of the pelvis), and the fascia of the Rectus abdominis. It's also worth noting that their fibers "cross-hatch" in opposite directions, thereby allowing movement through a variety of planes.

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Development of the Obliques

To keep things simple, I'm going to refer to the External Obliques and the Internal Obliques, just as "the Obliques" or the "Oblique muscle" - since they operate simultaneously.

The Obliques have several functions. They provide support for the internal organs and assist in breathing, in addition to causing torso rotation and torso flexion. However, the one primary anatomical movement that allows us to <u>build</u> this muscle, so that it's prominently visible, is Lateral Torso Flexion, also known as a "Side Bend".

The *Side Bend* movement is the best way to "stretch" (elongate) and contract (flex) this muscle. If we're on a bodybuilding stage, and we want to flex our Obliques, we flex our torso in the direction of those fibers, and squeeze. This "squeeze" (flex) can be felt between the side of the ribcage and the hip bone on the lateral side of the pelvis. That is where (more or less) a ***Side Bend*** exercise typically finishes its range of motion.

There are number of versions of a *Side Bend* - however, they each have a different degree of **productiveness*** - ranging from "waste of time" to "excellent". There is an "ideal" (best) way of doing a *Side Bend* - or, to be more specific - an **"ideal" direction of resistance** that can be applied to a *Side Bend*, which makes it maximally productive.

(Note: All Side Bends are "unproductive", if a person **expects** it to reduce, or diminish, the body fat that has accumulated on the side of their midsection. That will not happen, and the expectation that that will happen is completely misguided.)*

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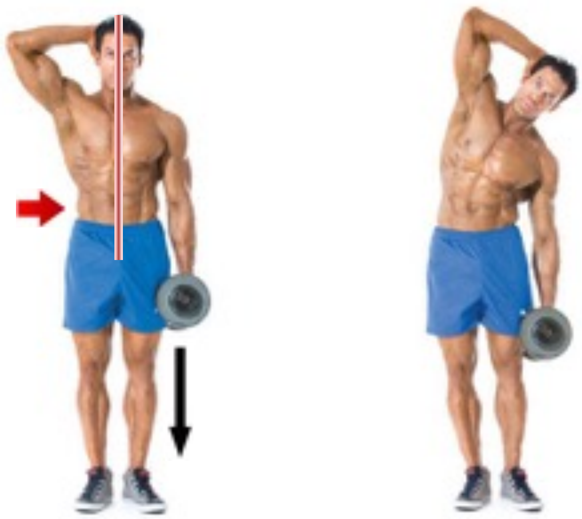
Below, we see a man performing a "standard" ***Side Bend***, while holding a dumbbell in his left hand. His left hand is on his head, but it doesn't need to be. It can be anywhere, as long as he's not holding another weight in that hand, thereby counterbalancing the movement. This is as correct as it could be - **however**, the direction of resistance **<u>not</u>** good. Let's analyze this.

The operating lever of the Obliques is the torso, just as the operating lever of the Biceps is the forearm. We've already established that the operating lever of a target muscle **should** cross resistance perpendicularly, somewhere in the range of motion. Clearly, that will **not** happen in this version of a Side Bend. At no point in the range of motion, will this man's torso be perpendicular with gravity (resistance). It is mostly parallel with the direction of gravity, throughout the entire exercise.

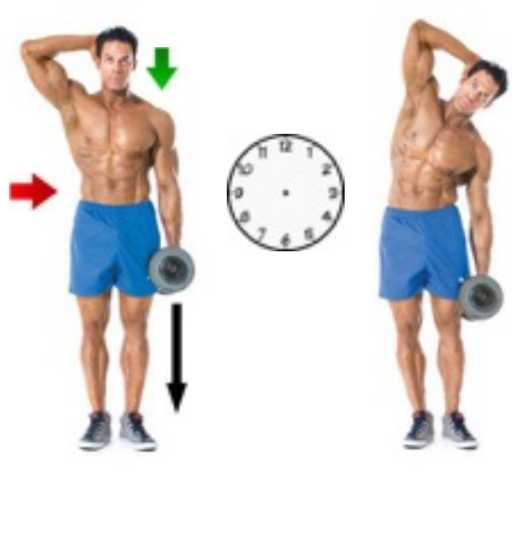
In the photo below, the **black arrow** indicates the direction of resistance. That dumbbell is being pulled straight down, by gravity.



The red **line** on the center of the man's torso (photo above left), highlights the fact that his torso (lever) is parallel with the direction of resistance. This means that - in this position - his Obliques (on his right side, red arrow) are mostly NOT loaded*, because the lever that operates those Obliques is in the neutral position, relative to gravity.

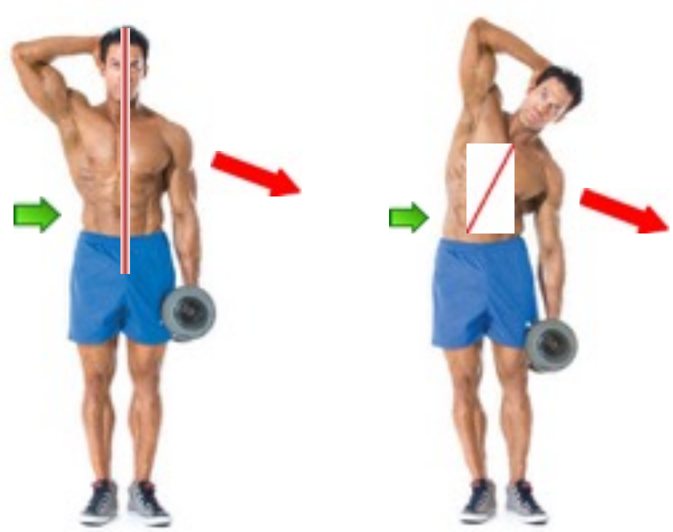
(Because the arm holding the weight is about 8 inches to one side of the center of his torso, there is some degree of sideways pulling, which is loading the right Obliques - but it's a fraction of what it could be, and should be.)*

Also, because of the rule of "Opposite Position Loading", the downward (6:00) pull of resistance will automatically load whatever is closest to the 12:00 position. His upper Trapezius (green arrow) is nearest that 12:00 position, so it is getting the greatest percentage of this load. The spine is also getting a large percentage of the downward pull, thereby compressing the discs - which is not good. But his right Obliques are at the 3:00 position, so they will only get a small fraction of the available resistance.



This is very inefficient. This version of a *Side Bend* is loading the target muscle (the Obliques) the LEAST, and non-target muscles (the Trapezius) the MOST. What's needed is a better (more efficient) direction of resistance.

In the photo below, I've placed a RED arrow at the shoulder - indicating a **better** direction of resistance. A cable would be used to achieve this. Notice how that red arrow, and the red line on the center of the torso, are more perpendicular? That means that the torso lever is more "active", and therefore a greater percentage of the load is placed upon the muscle that is operating that lever - the Obliques. Also, the right Obliques are now more on the opposite side of the resistance, so there's better compliance with "opposite position loading".



Is this the "ideal" direction of resistance? It's much better, but the "ideal" would be if the resistance came from a slightly higher angle - at shoulder level (below). That direction of resistance would provide a perfectly perpendicular angle from the torso at the mid-point of the range of motion, and would also allow a bit more "perpendicular-ness" at the conclusion of the movement - as compared with the version above.

Keep in mind that when the torso leans to one side or the other (without any addition of resistance), it would theoretically be on one side of the Apex, or the other. This means that it would tend to "fall" toward the side it's leaning. So, having a cable angle that originates from the height of the shoulder, would off-set some of the downward "fall" of the torso. It would be pulling the torso slightly upward, against which the Obliques would have to resist and contract - and that's great.

Range of Motion

Within the orthopedic / physical therapy communities, the “safe” range of motion for Lateral Torso (spinal) Flexion is believed to be 15 to 20 degrees. Compare this to the safe range for Forward Flexion (40 to 60 degrees) and Backward Extension (20 to 35 degrees).

The spine has LESS lateral mobility, than it does backward mobility. This is noteworthy. It is more common for people to experience lower-back discomfort from doing Side Bends, than from doing Back Extensions. So, caution is advised when performing Side Bends - especially in the stretch position (i.e., final eccentric phase of the range of motion).

Depending on how much weight one chooses to use when doing *Side Bends*, I would recommend omitting the first 20 to 40% of the range of motion. The 50% marker would be the half-way point, between all the way to the left and to the right. In other words, the 40% marker would be only slightly in the “stretch” direction - just past the vertical torso position. If the resistance is light, it’s probably safe to go to the 20% marker. However, full range on the contraction side would be safe - and also very productive.

As mentioned in the Abs chapter, it’s more safe to enter a full range of movement when it’s muscle contraction that is achieving that. It is not so safe to enter a full range of movement when it’s an outside resistance that is achieving that. **Allowing the cable resistance to pull you into a full stretch, is less safe than allowing your Obliques to pull you into a full contraction.** This is especially true when dealing with the spine.

Other Exercises for Obliques?

The exercise below is another version of a *Side Bend*. The position of the torso relative to gravity is different than that of the standing version. Theoretically, this resistance curve is better.

The torso is more perpendicular with gravity at the beginning of the movement, as compared with the standard (standing) version, using a dumbbell. In my opinion, it's too perpendicular, given the involvement of the spine.

I believe it would be better to have a little **less** resistance at the beginning of the range of motion, and a little **more** resistance at the end - due to the possibility of spinal strain. Remember, there is a higher risk at the extreme ends of the range of motion - but mostly when the spinal flexion is caused by an external resistance source, and when the resistance is increasing at that point - both of which are true here. Also, since this is a body weight movement, the resistance cannot be reduced - and it may be too much for some people.

For both of these reasons, using a cable would be better. One can simply adjust the pulley up or down, to select the resistance curve that is most comfortable and productive. Also, one can select the exact amount of resistance they want to use, instead of **having** to use one's entire torso weight.

(Note: The foot position is also not very comfortable, with the exercise above. One is ***obligated*** *to place one foot in front of the other, although a side by side footing would - in fact - be more comfortable and more stable.)*

The exercise above - known as the “Plank” - is a very common Oblique exercise these days. However, it is isometric - rather than dynamic - so the first problem is that it misses the benefits of dynamic muscle contraction. The second problem is that it’s a body weight exercise - “all or nothing”. For some people, this would be excessively difficult, and it does not provide the option of using a lesser resistance.

Beyond the lack of movement, and the lack of options for resistance level, there is also the discomfort (strain) placed on the shoulder joint, by having a large percentage of one’s entire body weight pushing the humerus into the shoulder socket. Many people with injured shoulders would not be able to tolerate this degree of joint stress.

In addition, that same amount of weight is pushing against one’s elbow. Yes - a floor mat would soften that a bit. But it’s simply unnecessary to place this kind of strain on the shoulder and elbow, when it’s just as easy to use a cable, from a standing position. In fact, this same exact position - even performing it as an isometric exercise - could be duplicated with a cable resistance, more comfortably.

Further, there is the issue of leg comfort. Proponents of the theory that *Leg Extensions* cause “knee shearing”, would say it’s bad to place a perpendicular force against the front of the ankle, because it might “shear” the knee. Yet, those same people don’t seem to worry a bit about applying the same kind of force against the **side** of the lower leg, which would theoretically force the knee to bend (“shear”) **sideways**.

Personally, I don’t believe this is a real concern either way - although it’s interesting to point out the irony. However, I do believe the Plank is unnecessarily uncomfortable on the legs, shoulder, neck and elbow - with **less benefit** than that which could be achieved using a dynamic Side Bend exercise, like the *Standing Cable Side Bend*.

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Additional Comments About Side Bends & Obliques

Many people believe that doing *Side Bends* will cause them to lose fat in the area of the Obliques. It will not. Side Bends work the Oblique muscle, under the fat. That fat must be addressed (diminished) by way of calorie intake and calorie spending. It cannot be “spot reduced”, “toned” nor “firmed”.

Lateral Torso Flexion (*Side Bend*) is assisted by a muscle called the “Quadratus Lumborum” - or the “QL”. It is a small, triangular muscle at the base of the spine (one on each side of the spine). People often have pain in this area, which is another reason why it’s not wise to force excessive stretch, with resistance, in either direction.

Lateral Torso Flexion (Side Bending), with limited range of motion, may be helpful for people experiencing QL pain. If you are experiencing lower back pain, and you are under the care of an orthopedic doctor or a physical therapist, ask them if your circumstances allow a “modified range of motion / Lateral Spinal Flexion”, before trying this yourself.

Lastly, ***Torso Rotation*** (shown below) is another movement that is caused primarily by the Internal and External Obliques. We often see people in the gym doing various versions of this movement. From a **functional** standpoint, this is a good movement - provided the direction of resistance is correct (red arrow, below). However, caution should be used to not **over-rotate** (excessively twist) the spine. Try to stay in the middle 80% of the range of motion (of *Torso Rotation*), and avoid the extreme stretch that assisted (forced) by resistance.

Although torso rotation has functional benefits, it is not likely to produce much - if any - **visible** development in the External Obliques.

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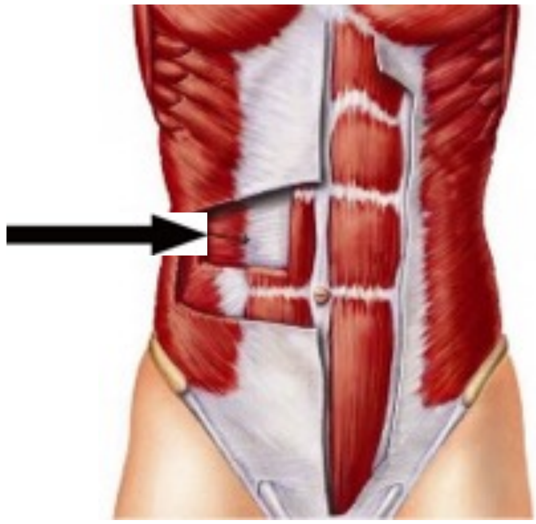
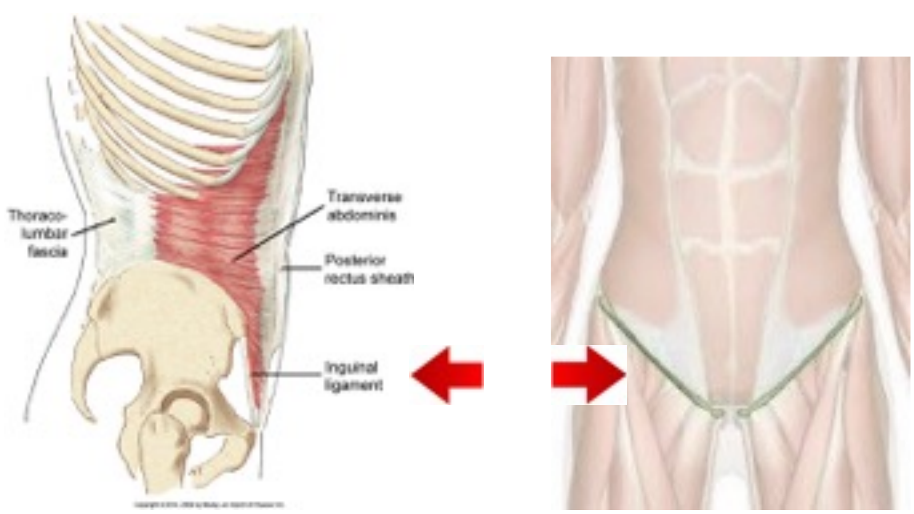
Transverse Abdominis



This muscle is essentially the third layer of abdominal muscle, from the surface. It lies beneath the Internal Obliques, which lie beneath the External Obliques.

In the illustration below-left (side view), we can see this muscle mostly connects to and from fascia. There are some connections to the ribs and the upper edge of the pelvis (boney areas), but since the fibers run horizontal to the torso, and the horizontal connections are from fascia to fascia (and also on the “Inguinal ligament”, which is a cord on the front of the pelvis - shown below right), it does not produce any actual skeletal movement. Rather, it acts as a sort of “girdle” for abdominal and spinal support, assists in breathing, and helps coordination. For a muscle to produce skeletal movement, it needs to attach to bones, which are drawn toward each other, upon muscle contraction.



Because the TVA (Transverse abdominis) is three layers deep, and cannot be seen, one might argue whether it's worth exercising this muscle. However, of the various muscles which are associated with "The Core", the Transverse abdominis is the muscle that is most responsible for the **characteristics** attributed to The Core - spinal and abdominal support, and coordination.

The only "direct" exercise that can be done to strengthen this muscle, is the **Abdominal Vacuum**. This is an exercise where the abdomen is drawn inward, and held. The best way to do this is either while lying down, or while bent over leaning against a table. First exhale completely, and then (without inhaling) draw the abdomen inward and hold for a few seconds - and repeat. The more one practices it, the more control one gains in doing this.

The "Vacuum" can also be performed as a pose on the bodybuilding stage. The bodybuilder most famous for this particular pose is Frank Zane - who's Vacuum pose was considered iconic (below).

In addition to assisting in breathing, abdominal control and spinal support, the TVA plays a role in micro-coordination of torso movement. The best way to improve that function is by doing athletic activities - hiking, dancing, basketball, volleyball, tennis, etc. These activities require constant microscopic adjustments in **posture**, which allows one to move their arms, legs and torso, while simultaneously not falling. Thus, these activities improve our "proprioception".

In Chapter 15, we discussed the difference between "balance" and "proprioception". The distinction between the two can get a bit murky. We often use the term "balance", when what we mean is coordination.

This is why my recommendation has been to do more athletic activities, rather than spend a lot of time standing on a wobble board, or on one leg, compromising our efforts to lift weights. Athletic activities improve proprioception and coordination (i.e., our Transverse abdominis) much better than unstable weight lifting.

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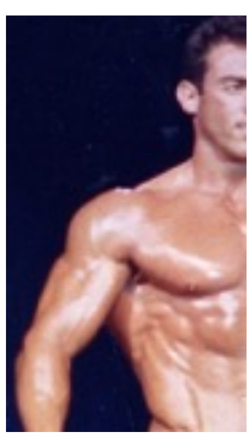
Shoulder Rotators

(also known as the "Rotator Cuff" muscles)

I left this group of muscles for last, because they are not normally considered "physique muscles". Yet, understanding these muscles - when they participate, when they should not participate, and what leads to their inevitable strain - is extremely useful in the application of exercises used for physique development.

The four muscles involved in the integrity of our shoulder function are the **Supraspinatus**, the **Infraspinatus**, the **Teres Minor** and the **Subscapularis**. These muscles hold the head of humerus (upper arm bone) in the Glenoid fossa (shoulder socket), and rotate the humerus internally (forward) and externally (posteriorly).



The illustration above-left, shows the perspective we'd see if we were looking at someone's front, and could see through their chest cavity, at that inner part of the shoulder blade. The illustration above-right, shows the perspective we'd see if we were looking at someone from behind, and could see the back side of their shoulder blade through their skin.

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Supraspinatus

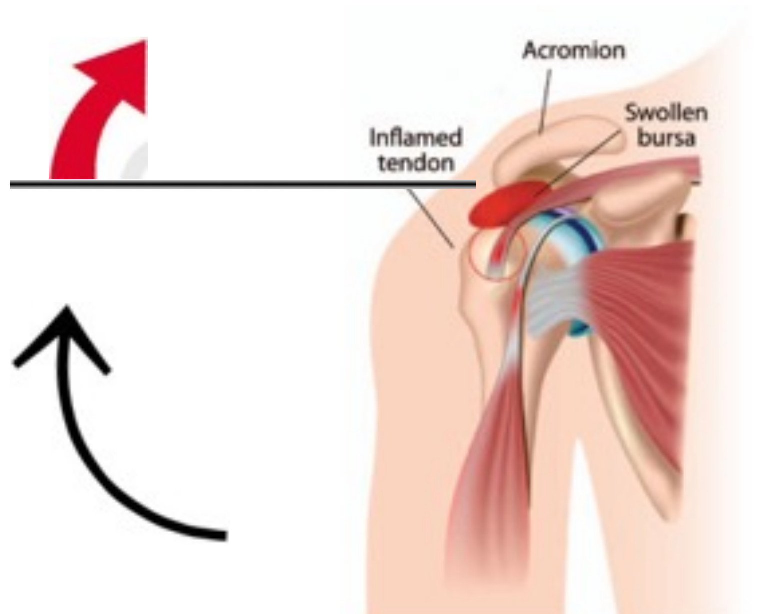
The **Supraspinatus** is a muscle that runs along the top of the scapula. It originates on the inside edge of the top of the scapula, and then passes under the Acromion process, and attaches onto the upper / outer part of the humeral head.

When this muscle contracts (remember that all muscles pull toward their origins), it pulls the upper outer head of the humerus, inward. This produces the first 10 degrees of lateral abduction of the humerus - assisted by the Lateral Deltoid, of course.

The problem most often associated with this muscle - actually, with its tendon - is called "Impingement Syndrome".

In the illustration below, you can see that the "**Acromion**" is a bone (part of the scapula) just above the head of the humerus.

Also, in this illustration, you can see "**Inflamed tendon**", which is referring to the Supraspinatus tendon. You also see the "**Swollen bursa**" (aka "Sub-acromial bursa").



The tendon and/or bursa become irritated and inflamed when the humerus (upper arm bone) is frequently raised higher than the Acromion process (indicated by the red arrow, below). The tendon and the bursa get **squeezed** between the humerus and the Acromion. Sometimes this results in a rupture of either the tendon or the bursa.

If you were to do an internet search on “the most common cause of Impingement Syndrome”, you would find that it is caused by, “repeatedly moving the upper arm overhead”.

“Repeatedly moving the upper arm overhead”, is precisely what occurs when we do Overhead Presses. There is no way to perform an Overhead Press without raising the upper arm higher than the Acromion process.

If it was **not possible** to develop the Deltoids **without** doing Overhead Presses, some people might say “it’s worth the injury risk”. However, doing Overhead Presses is NOT the only way to develop the Deltoids. It’s not even the “best way” to develop the Deltoids. In fact, it’s an outdated exercise that was “grandfathered” into bodybuilding by former Powerlifters and people who performed “strength exhibitions”. It was naively embraced by bodybuilders who did not understand biomechanics, in the late 1800s and early 1900s. And has it been passed on through tradition.

Of course, many people (mostly men) enjoy doing Overhead Presses because it allows them to lift a large amount of weight. That’s fine - except for the fact that moving a large amount of weight by incorporating several muscles, is no better **for bodybuilding benefits** than lifting a lesser amount of weight with only one muscle. Why do an exercise that is **not necessary** for bodybuilding, and has a much higher risk of injury?

Yes - some men like the idea of having BOTH - big muscles and also being perceived as “strong”. Notice I said “perceived” as strong. You can have large, well developed muscles - and you can also have muscles are individually strong - and still not do Overhead Presses. Moving a large amount of weight by way of incorporating several muscle groups at one time is almost like using a Pry bar to lift a heavy box. It does not necessarily prove the strength of the individual muscles.

Unfortunately, people have adopted the Overhead Press (like the Bench Press) as a standard measuring tool (a "barometer") of strength, against which they can compare to other people's Overhead Press results (amount of weight lifted). Personally, I feel that that comparison is fairly meaningless, in the scheme of life. It's good to be strong, of course. But how my strength compares with the strength of others (assuming I am "strong enough"), is largely irrelevant to me.

Overhead Press has its place. It is **useful** in Powerlifting, as well as for people who are training to compete in sports which mimic that sort of movement - like Shot Putting. Unfortunately, "useful" does not mean safe. It simply means that it's an effective movement for a few, very specific performance goals - but at a cost.

Those seeking optimal muscular development, while simultaneously seeking to maintain the integrity of their shoulder joints, should be aware of the fact that the Overhead Press is very inefficient for developing the Deltoids, and it has a high probably of causing **Impingement Syndrome**.

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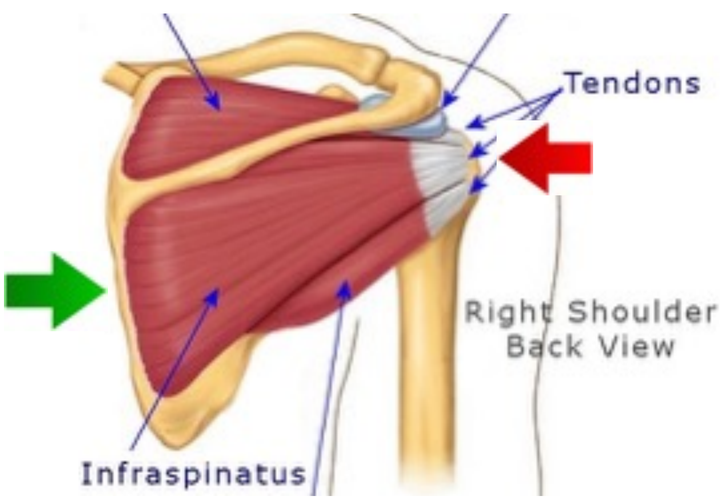
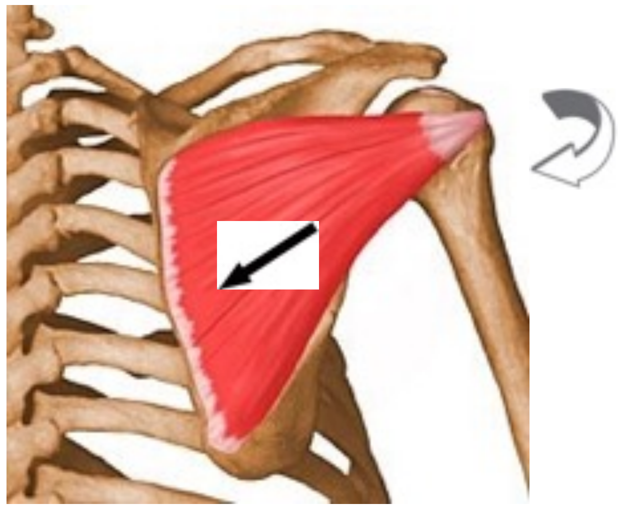
Infraspinatus

The **Infraspinatus** is the second-most vulnerable muscle of the Rotator Cuff group, among bodybuilders.

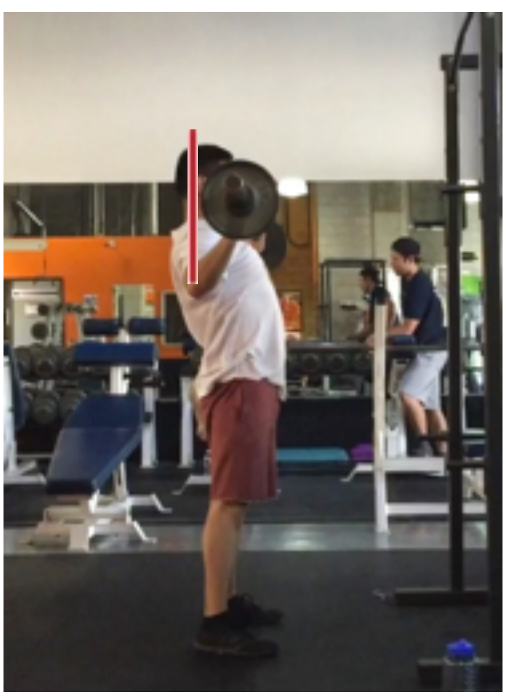
This muscle covers most of the posterior side of the scapula. It originates on the inside edge of the scapula (green arrow, below) and stretches across the shoulder joint. It then attaches around the back side of the humeral head (red arrow, below).

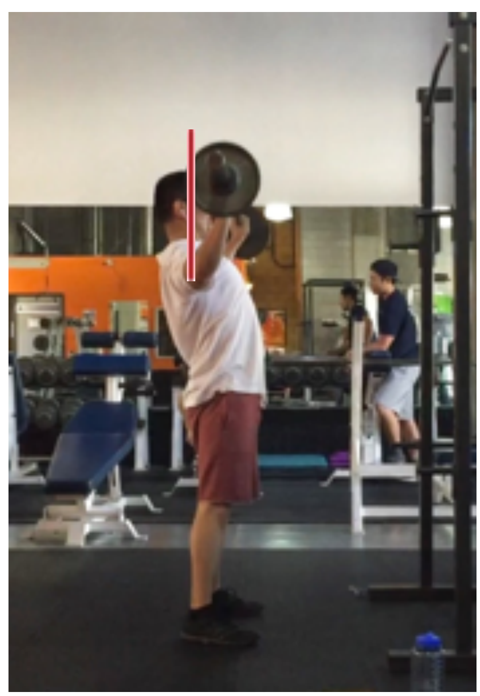


When this muscle contracts, it pulls its insertion point toward its origin. Imagine this happening in the illustration below. Notice the direction of the fibers. The muscle will inevitably pull the humeral head, in that semi-diagonal direction toward its origin, thereby causing **external rotation** (grey curved arrow) of the humerus.



Now, let's see what happens when a person performs an exercise - intended to work the Deltoids - in a way that strains the Infraspinatus.

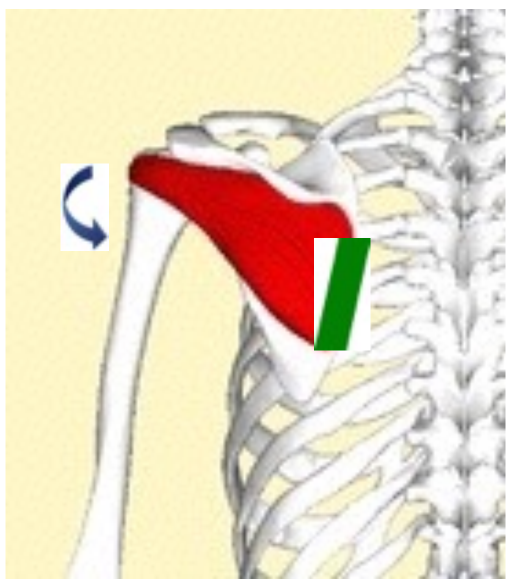




In the two photos above, we see a man doing Overhead Presses. Notice how he allows his forearms to tilt forward, during the motion. He does this, in part, so he doesn't hit his head with the barbell. His forearms are tilted more at the bottom of the repetition (above-left), but they are still tilted forward even at the midway point (above-right). The vertical red line indicates where his forearms **should** be, in order to be "neutral".

A forearm that is held vertically (during an Overhead Press) would be "neutral", and would NOT force humeral rotation. However, a forearm that is tilted forward (during this exercise) acts as a wrench handle, trying to rotate (twist) the humerus forward. The **Infraspinatus** is forced to resist this forward rotation, and tries to rotate the humerus back, so the forearm can be neutral. This is like "reverse arm wrestling".

Under normal circumstances - when the humerus is down alongside the torso (below) - any rotational force exerted by the Infraspinatus, on the humerus, is from a Mechanical Advantage. In other words, the Infraspinatus is able to pull **straight toward** its origin (shown below as a green bar), and easily produce external rotation of the humerus.



However, when the arm is NOT down alongside the torso - when it is perpendicular to the torso (as is the case during Overhead Presses - shown below) - the origin of the Infraspinatus is not inline with the direction the humerus must be rotated. The Infraspinatus must try to rotate the humerus downward (blue arrow below), even though it is positioned "inward" (green bar). This Mechanical Disadvantage creates a significant increase in the force requirement. So, even though the forearm may only be tilting forward a tiny bit, the magnification caused by the length of the forearm, combined with the Mechanical Disadvantage of the humeral position, could easily overwhelm and and injure the Infraspinatus.

The same thing could occur during Supine Dumbbell Presses, shown below. A forward tilt on the forearm (even though unintentional), will produce a forward rotation on the humerus, against which the Infraspinatus must struggle to prevent. And, since the origin of the Infraspinatus is not in line with the rotation of the humerus, it must pull from a side angle - which requires significantly more force.

This same thing could also occur during an Incline Press or a Decline Press. Any time the upper arm is in the position that is perpendicular to the torso, and the loaded forearm is allowed to tilt forward from the vertical position, there is a chance the Infraspinatus will inadvertently become over-loaded, strained or torn, as it tries to resist further forward rotation of the humerus.

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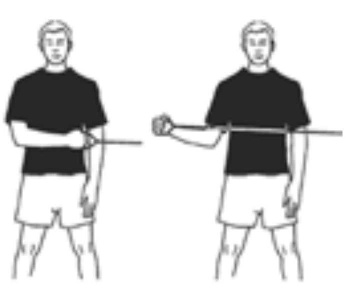
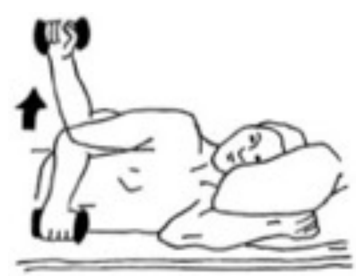
Exercising the Infraspinatus

Having established that rotation of the humerus is BEST performed (most efficient and safest) with the humerus down alongside the torso, the exercise below would certainly NOT qualify as one of the better exercises for the Infraspinatus.

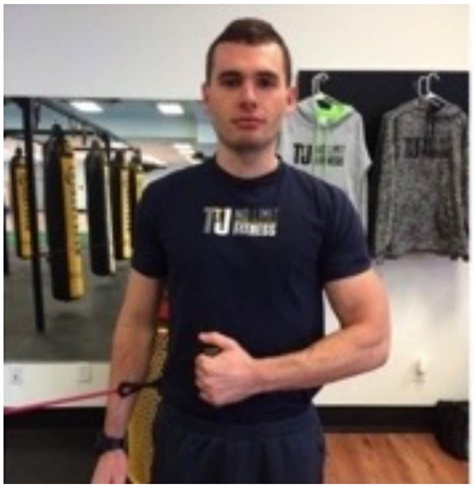
Again, attempting to externally rotate the upper arm when it is perpendicular to the torso, places the Infraspinatus at a tremendous Mechanical Disadvantage. It is extremely inefficient for the Infraspinatus to pull on the humeral head, in the direction it must rotate, while having its origins **<u>not</u>** inline with that direction of rotation.

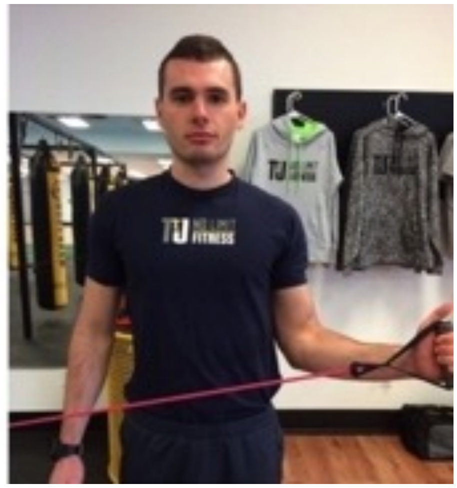
The two exercises below are one step to closer toward “correct” movement, because (at least) the humerus is held alongside the torso, while it’s being rotated. However, there is problem with these versions as well.



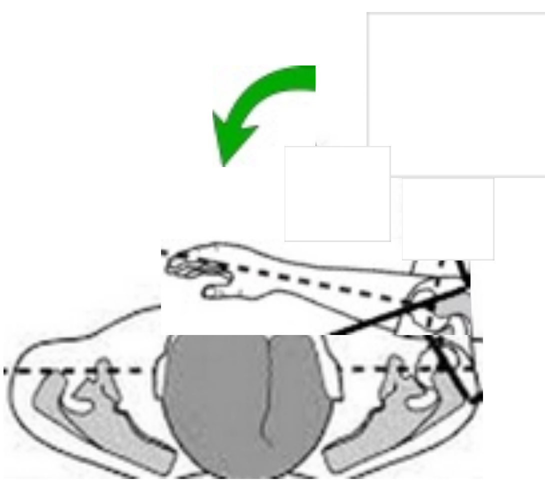


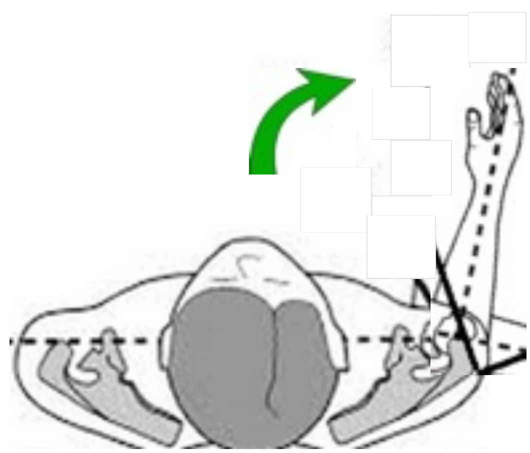
Let's do this little experiment together. Stand in front of a mirror, with your right arm alongside your torso. Now, bend your elbow to 90 degrees - as if you are halfway into a Biceps Curl.





Now, ensuring that your elbow is held tightly against your side, allow your humerus to rotate "internally" forward, as far as possible. You'll find that you can easily bring your forearm all the way, so that it's up against your abdomen - while still keeping your elbow pressed against your side. However, you will not have the same degree of mobility rotating your humerus "externally". It may only rotate to the point where your forearm is pointing straight ahead, or it may allow your humerus to rotate enough so that your forearm is 10 or 15 degrees past that "straight forward" point - provided you keep your elbow tightly against your side. So, the range of motion depicted in those two exercises above, is "excessive" - to be totally comfortable and safe.





The range shown above represents a normal, natural, safe range of humeral rotation. Forcing the humerus to rotate farther out (laterally) than the range shown above - unless it's completely comfortable - will only cause irritation.

So, now that we know the "ideal" anatomical motion, and we know the "ideal" range of motion, let's apply the principle of "early phase loading" - in selecting the "direction of resistance".

In the case of those exercises shown above - the one using the elastic band (on the left), and the one lying on one's side with a dumbbell (on the right) - both of them encounter the "maximally active position" (the lever being perpendicular with resistance) when the forearm is pointing straight ahead. But, as we now know, that is at (or near) the end of the natural range of motion. That's where the Infraspinatus is "weakest".

When the humerus is rotated all the way inward, the Infraspinatus is the most elongated, and therefore the "strongest". Yet, in both of those exercises above, that's the point where the forearm enters a mostly neutral angle to resistance, thereby diminishing the resistance, and depriving the Infraspinatus of the opportunity to be more loaded.

The solution is simple - change the position of the body, relative to gravity, so that the resistance curve provides "early phase loading" and "late phase easing". This is shown below.

When I do this exercise above ("***Lying External Humeral Rotation***" w/dumbbell), I start with a 3 pound dumbbell for 50 repetitions (each arm, separately). Then I move to a 5 pound dumbbell for 40 repetitions; then a 7 pound dumbbell for 30 reps, a 9 pound dumbbell for 20 reps, and a 12 pound dumbbell for 15 reps. A total of 5 sets, every few days.

Let me also remind you that - when we were discussing the muscles of the "Upper Back" - I showed you this photo (above), highlighting the **Infraspinatus**. This is the only "Rotator Cuff" muscle that is actually visible and prominent. The Teres minor is also visible, but it's small and not prominent; the Supraspinatus and Subscapularis are not visible at all, because they are beneath other layers of muscle and/or skeleton.

So, the "External Humeral Rotation" exercise I recommend above is not only good for the sake of shoulder joint integrity. It's also good for physique display.

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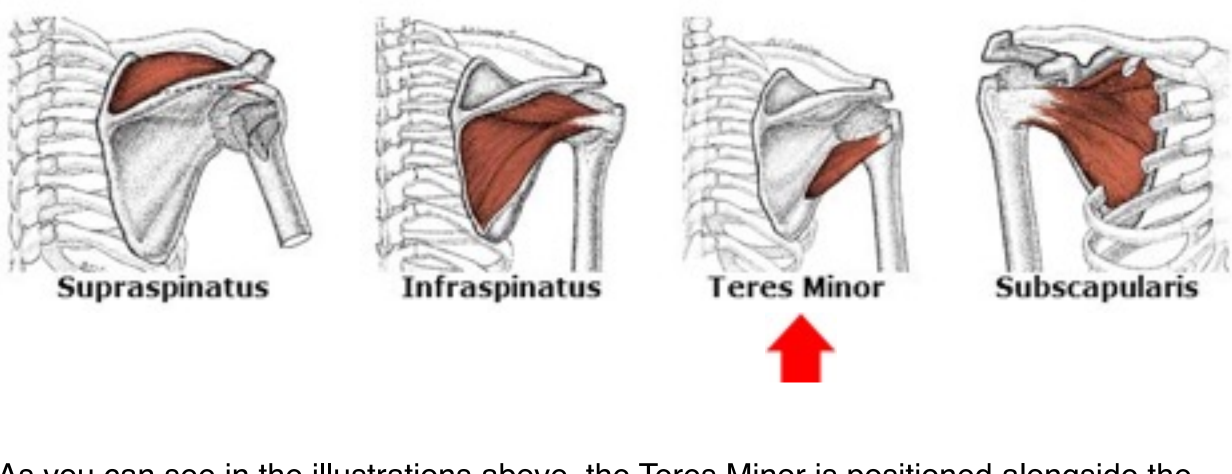
Teres Minor

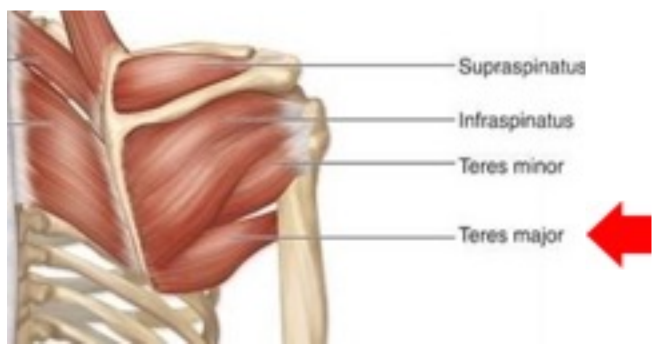


As you can see in the illustrations above, the Teres Minor is positioned alongside the Infraspinatus. Its origin is closer to the outer edge of the scapula, whereas the origin of the Infraspinatus is on the inner edge of the Scapula. But they are mostly side-by-side, and the insertion points are also side-by-side on the humeral head. Like the Infraspinatus, the Teres minor is an external humeral rotator. However, it is clearly a smaller, weaker assistant to the Infraspinatus, in that task.

When we are performing "***Lying External Humeral Rotation***" w/ dumbbell for the Infraspinatus, the Teres minor is benefitting as well.

The **Teres major** (shown below, alongside the Teres minor) is not considered part of the Rotator Cuff group. Its attachment is lower on the humerus, so it has some "leverage" on the humerus. This makes it primarily a humeral **adductor**.

However, as you can see below, its attachment is on the "inside" of the humeral shaft, and its origin is on the posterior side of the scapula. So, it DOES to produce some degree of INTERNAL humeral rotation. However, its primary function is pulling the humerus down and back. It participates in any motion that engages the Lats or the Posterior Deltoids.



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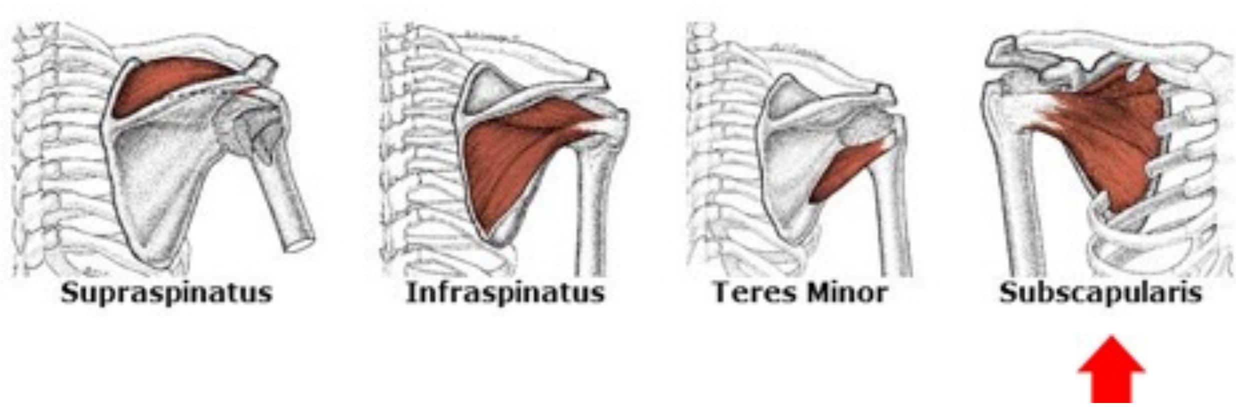
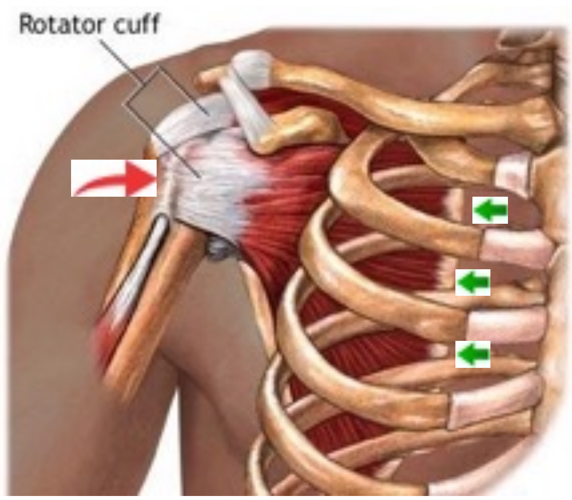
Subscapularis



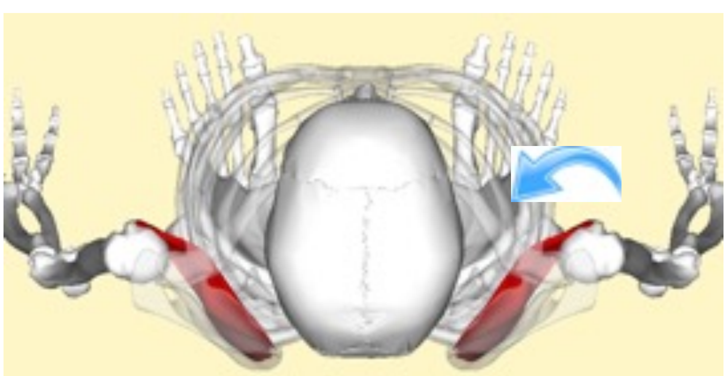
The illustration of the Subscapularis (above - far right) is a view from the front - as if we could see through the chest cavity and ribs of the person. We are looking at the ANTERIOR view of the scapula.

The **Subscapularis** is on the <u>inside</u> of the scapula. It originates on the inside edge of anterior wall of the scapula (small green arrows below), and attaches onto the Lesser Humeral Tuberosity (red arrow, below).

The illustration below shows how the Subscapularis is tucked **between** the anterior wall of the scapula and the posterior side of the Ribs. In this view, you can also see how this muscle's attachment wraps around the **anterior** side of the humeral head. So, when this muscle contracts, it pulls that outside edge of the humeral head, toward the origin of the Subscapularis, thereby ROTATING the humerus "internally" (toward the front).



Also on the illustration above, we can see the Supraspinatus tendon, as it comes out from under the Acromion, and attaches onto the top portion of the humeral head. The other two Rotator Cuff muscles (Infraspinatus and Teres minor) would not be visible from this view, as they are both on the posterior side of the scapula.

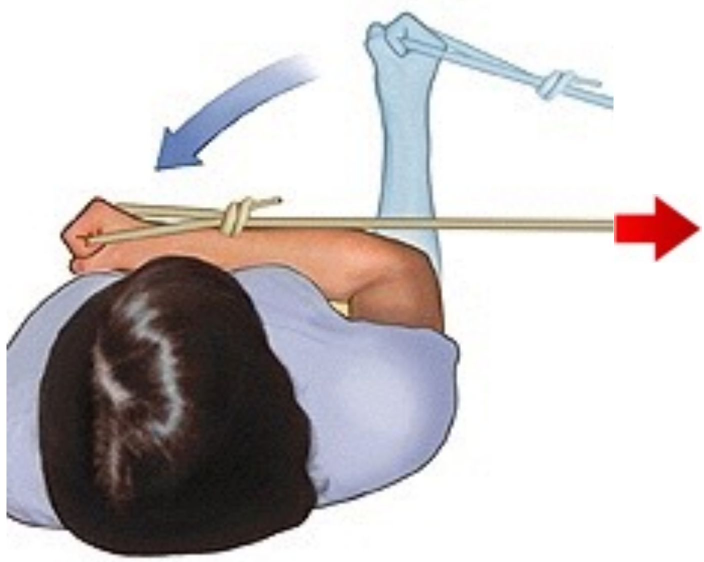


Above is an overhead view, which allows us to see the Subscapularis muscle (shown in red) originating on the inner edge of the anterior wall of the Scapula, and then attaching onto the front of the humeral head. I've placed a blue arrow, showing the the action that would occur when this muscle contracts (shortens), internally **rotating** the humerus toward the origins of the Subscapularis.

The Subscapular is never be visible, obviously. So the rationale for working this muscle would be to maintain the strength and integrity of the shoulder joint, and also for sports that specifically involve forceful inward rotation of the humerus - which includes any "throwing" sports.

Similar to the discussion regarding the Infraspinatus, the Subscapularis is able to function with a Mechanical Advantage, only when the upper arm is alongside the torso. Therefore, this is the best humeral position from which to work this muscle - for general conditioning.

Below is an overhead view of a person performing "Internal Humeral Rotation", with an elastic band. Notice that the range of motion is the same as that of "External Humeral Rotation". However, the direction of concentric movement is the opposite of that which is used for External Humeral Rotation.



The direction of resistance shown here is good, because it provides "early phase loading" (perpendicular lever at the beginning of the range of motion), and "late phase easing" (mostly parallel lever at the conclusion of the range of motion). Cables would ideally be better than an elastic band. But an elastic band would be acceptable.