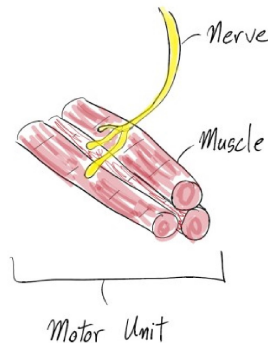


The Motor Unit- The Basics of Control

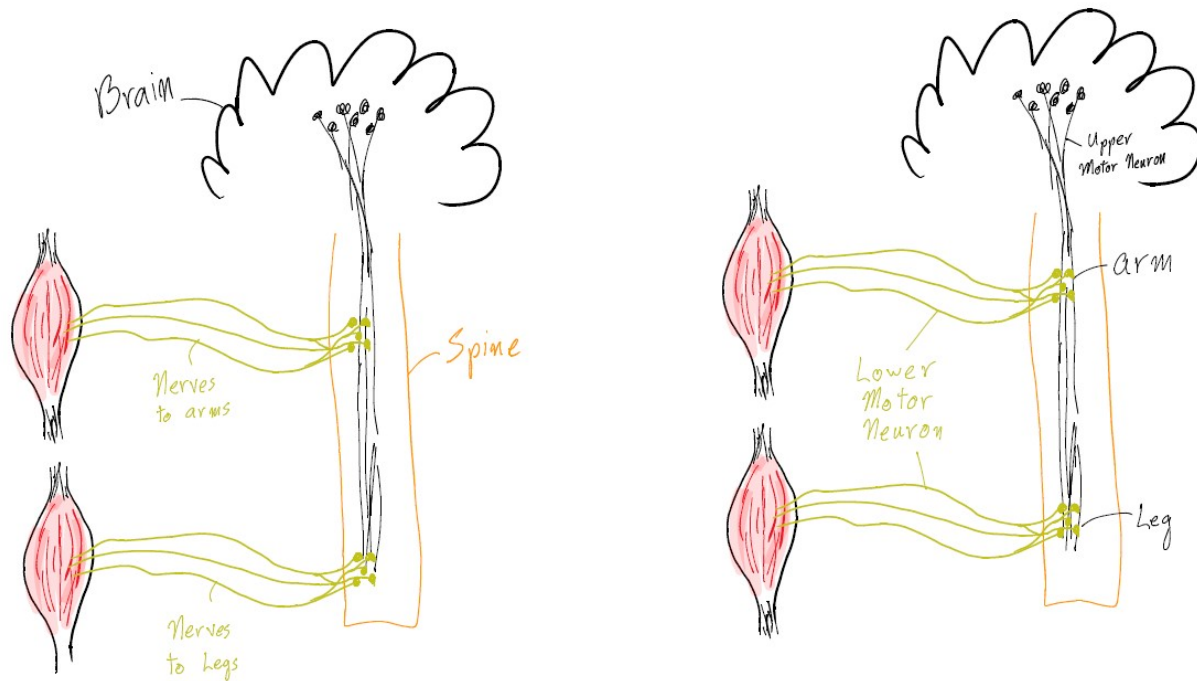
Touch your nose gently...go ahead do it. Now touch your nose with all your muscle strength...no no no! just kidding, bad idea. Imagine if your muscles worked as one big on/off switch and you either used full power or no power. That would be terrible and you would punch yourself in the nose all day. **Individual muscle cells are either 100% on or off.** Trying to control each of the millions of muscle cells individually would be impossible. So your body makes groups 10 to 1000 muscle cells that are all controlled by one nerve cell. **The combination of these muscle cells and that one nerve that controls them is called a motor unit.**



Now that we have our organization, we need to understand its control. **The reason a swimmer needs to learn all this is because different motor units are used differently.** And that plays a big role in training. Let's start from the top...literally.

The Nerve Highway

Anatomy can get real complicated real fast, but for today we can focus on three major parts: **The brain, the spine, and the nerve.** Don't worry about the cerebellum or the thalamus or the basal ganglia...we'll touch on those in the Motor Learning chapter when we talk about motor patterns (which is a fancy word for technique...at least for swimmers that's all it means).

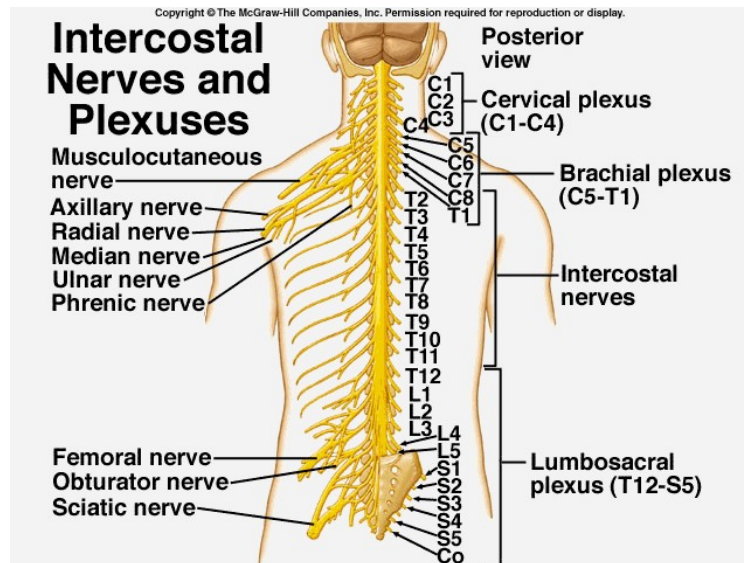


The brain contains 100 billion nerves, specifically their cell bodies. **The cell bodies that control muscles extend an “arm” all the way from the top of your brain to the spine.** The technical name for this nerve is the Upper Motor Neuron.

Tangent: These nerve “arms” are called axons, and they send the electrical signal that activates whatever the nerve is connected to: muscle, other nerves, or glands. These axons are an extension of the nerve cell body, kind of like very long “arms” that reach out and give “handshakes.”

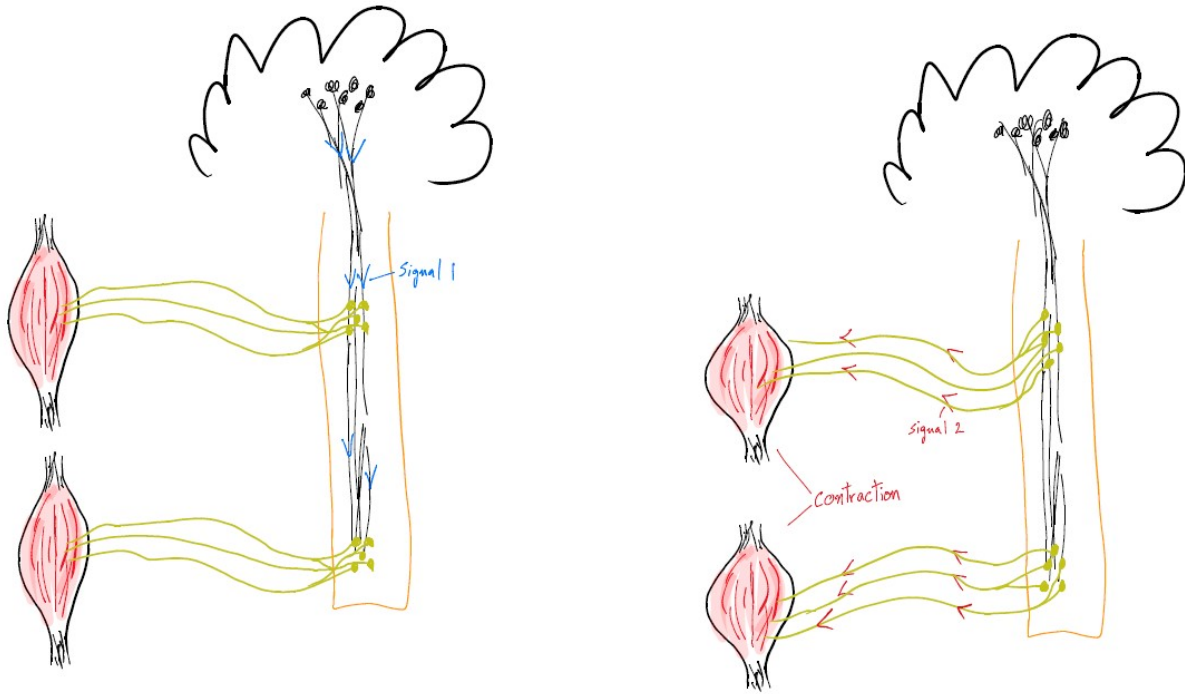
In the spine, the “arm” meets up with another nerve’s cell body and connects to it. **This nerve then sends another “arm” out of the spine and to the muscle cells it connects to.** This is the Lower Motor Neuron.

A whole bundle of “arms” from the Lower Motor Neurons make up the nerves that travel throughout your body. You can feel one of these bundles easily on the inside of your elbow, just smack it on something hard and your Ulnar nerve (the “funny bone”) will let you know it’s there (or you could keep you elbow bent for 30 minutes and watch your ring and pinky finger fall asleep, a common occurrence among teenagers who spend too much time talking on their phones...)



Why do you need to know this highway of communication? **Because swimmers need (and have the ability) to train all parts of it and make it better.** Motor patterns are mainly a “brain” thing and involve the upper motor neurons and we will go in depth about them in BOS-II. But for now, understand that the upper motor neuron (the one in your brain) is responsible for starting a muscle contraction. Everything else below that is just a game of telephone.

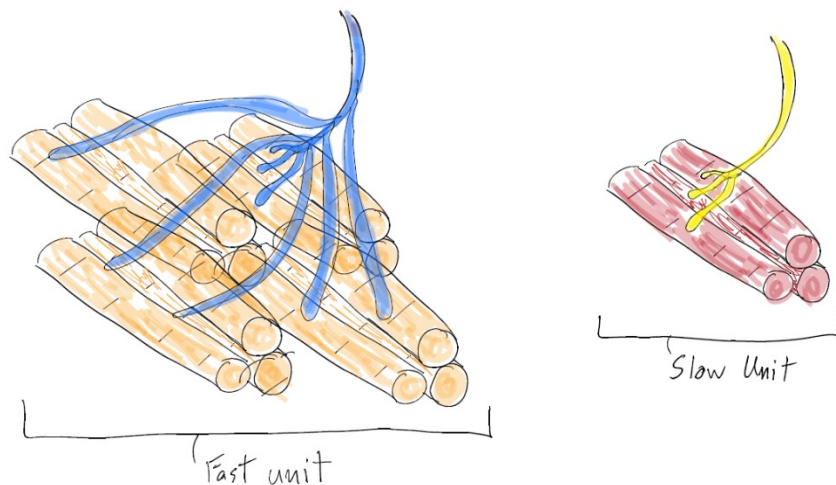
When the upper motor neuron’s signal reaches the lower motor neuron in the spine, the spinal neuron sends out its own signal that travel’s down its “arm” and directly tells the group of muscle cells it controls to contract. That is how a motor unit (nerve + muscle) is activated. Depending on the strength of the brain signals, the frequency of the spine signals, the type of motor unit being activated and whole bunch of other factors, **this determines which motor units will fire, and how much strength will be produced by that muscle as a whole.**



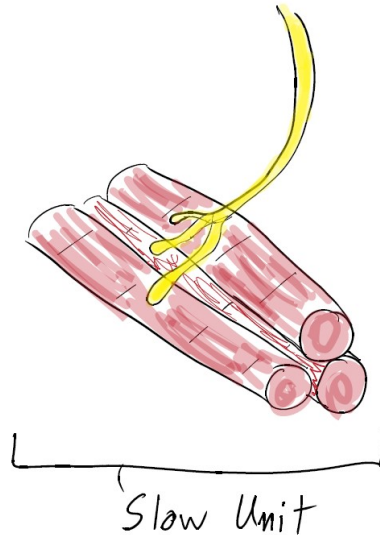
That's it! That's the motor neuron highway, you're ready for your biology test. But how does this work in the pool? Let's go one step further in our understanding shall we.

Motor Units Big and Small

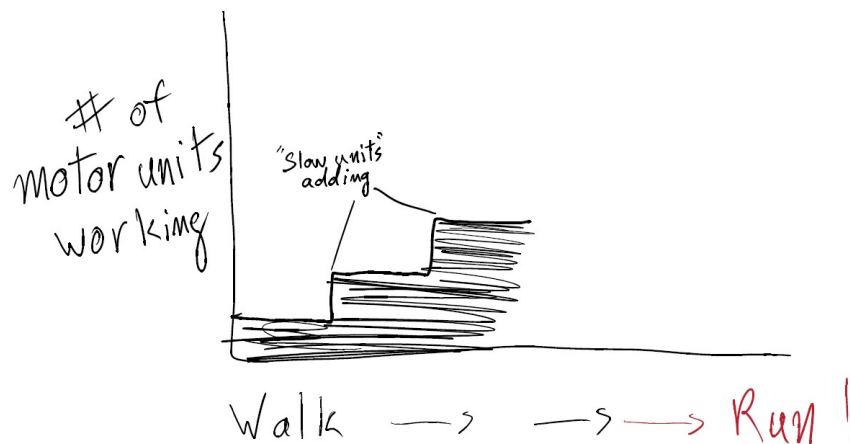
If you remember from our last chapter on Muscle Types (slow and fast), you will know that the nerve is what controls what type of muscle fiber the cell will be. That means **all the muscle fibers in the same motor unit, which are connected to the same nerve cell, are exactly the same**. They are either all slow twitch, all fast twitch or all something in between. For simplicity, we will call these "slow units" and "fast units."



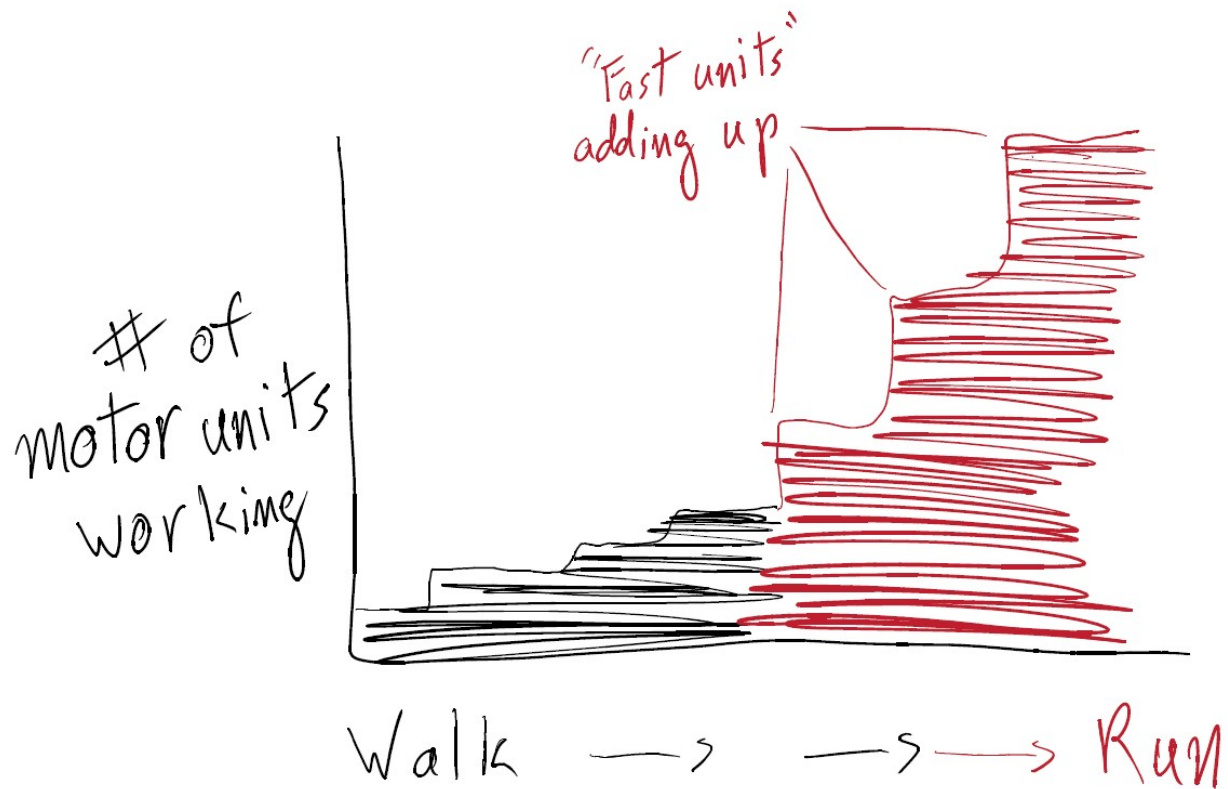
There is a reason for all this very specific organization. Imagine you want to go for a walk. That doesn't take a lot of muscle power, and your body is ALWAYS trying to conserve as much energy as possible. So, **it only activates the motor units it needs to.** These “low threshold” units are all made up of “slow twitch, slow nerve” motor units.



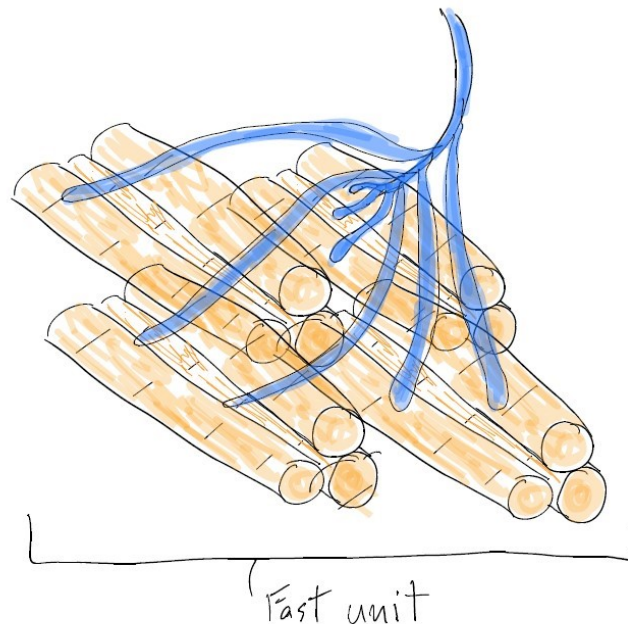
That makes perfect sense. These are the muscles you will use most of the time in your life to do most chores. The last thing you want is for these to be big fat fast twitch fibers that will overpower every movement and run out of energy after 30 minutes of use (remember slow fibers use mitochondria and fat, so they are very efficient at making ATP). **These “slow units” are arranged in small bundles of muscle fibers, usually 10 to 100 fibers at a time, and are very easy to activate and control, and they never run out of energy.**



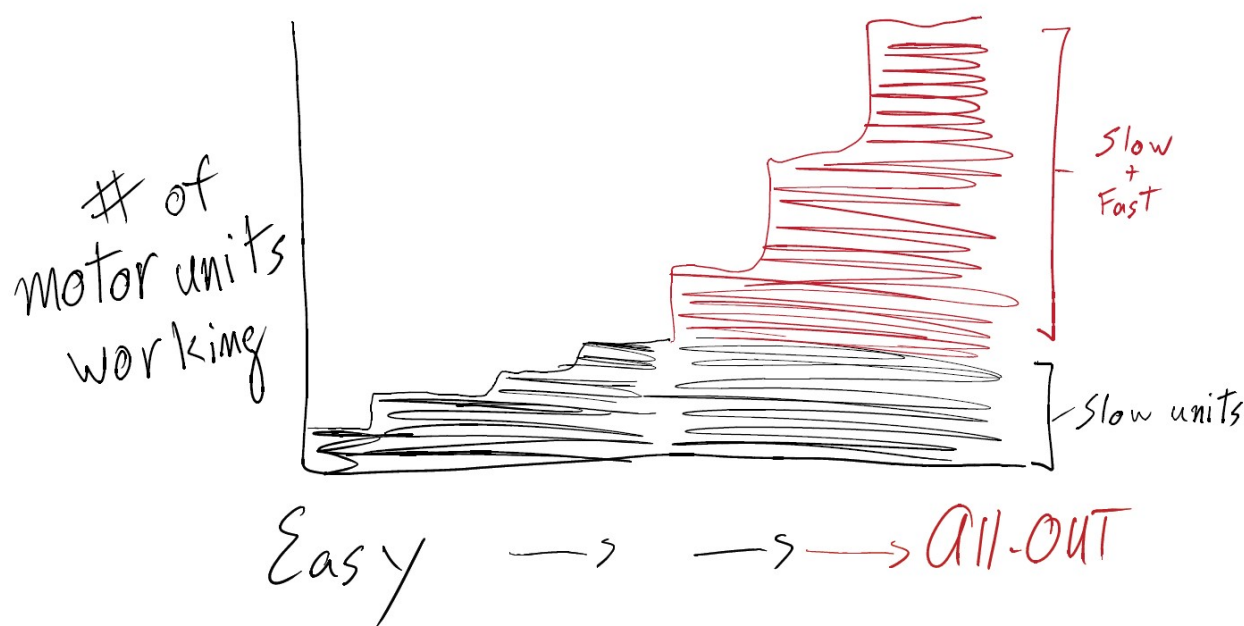
On your relaxing walk a lion suddenly jumps out of the bushes! It's time to run. No conservation, no holding back, time to activate the rest of the motor units. **With the massive increase in signal from the upper motor neurons, most of the lower motor neurons and motor units start firing for maximal contraction.**



These motor units that were “dormant” are made of large groups (100s to 1000s) of muscle fibers and are mostly fast fibers that are extremely powerful but won’t last long. These motor units are controlled by nerves that are very difficult to activate and require a large signal from above to turn on. This also makes sense, these are motor units you only want to use when you need them.



This phenomenon is called “recruitment” because as the demand on a muscle goes up, the body sequentially “recruits” more and more motor units to do the job. This is additive, meaning the lowest “slow unit” is always active with every activity, and big “fast units” are recruited and add on to the lower motor units so they are all turned on at the same time. This is why your coach makes you sprint so much! **If you just swam easy all the time, you would only be using the “slow units” and those would be the only ones that got any training.** During an all-out sprint and pace sets is when you start using the bigger “fast units.” And always remember: **what you don’t train won’t improve.** And we are all about improving, right?



This also explains why paddles and fins work so well. While these pieces of equipment improve your efficiency in the water by increasing your distance per stroke/kick...**they also require that you use a lot more motor units to overcome the added grip on the water.** Using paddles or fins, even at an “easy” pace will provide training to a lot more motor units vs. if you just swam easy without the equipment.

This also explains why “recovery days” are not what you think they are. Ever had coach say “Hey! It’s recovery day” and then write up an 8000 yard work out? **Even 8k at an easy pace will really only use the “slow units” which run a lot on fat.** This gives a day off for those “fast units” that used up all their sugar in the last workout. See? Coach knows.

Different Strokes Means Different Motor Units

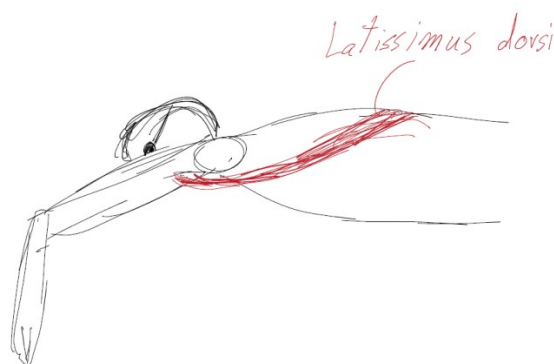
Have you ever raced at a meet where you improved in your best stroke but all the rest were flat? I mean it’s all swimming right... if you get good at freestyle it should carry over to the other strokes, correct?

Kind of.

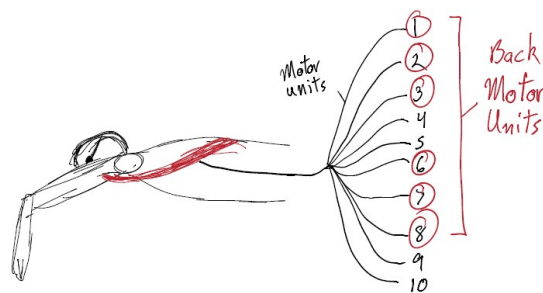
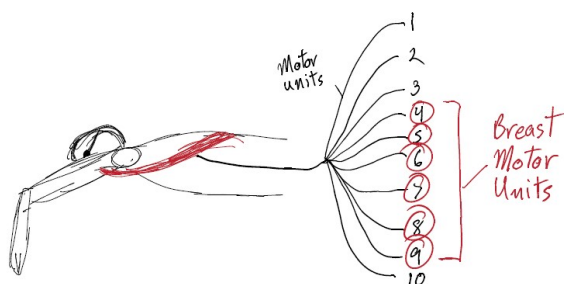
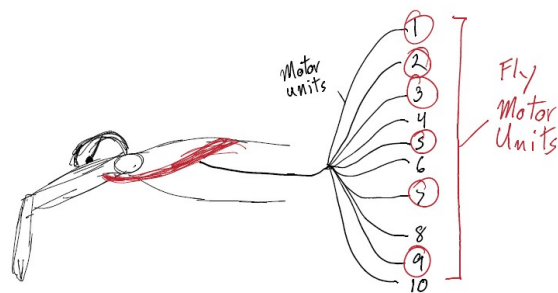
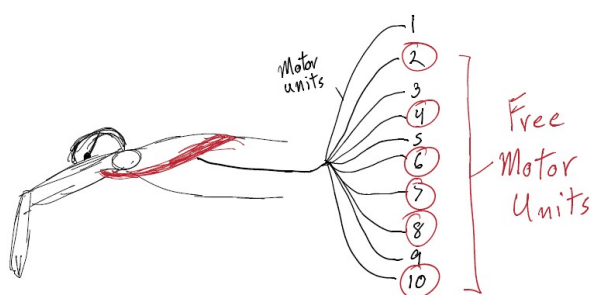
Yes there is a bit of cross-training between strokes and yes... the picture is more complicated when you include improvements in cardiac and capillary function (Cardio chapter), but **on the muscle side of things, swimming freestyle is not the same as swimming the other strokes** and here is why.



If we look at how your latissimus dorsi (Lats for short) work during each of the four strokes, we would find that **each stroke uses its own set of motor units**. While it is easy to think of your Lats as a single muscle that fires the same way every time no matter the stroke, it is too simplistic. Your Lats (which do the bulk of the work in swimming) are made of millions of muscle cells and motor units which are arranged just a little differently and in different directions. **So the motor units you use for breaststroke, and not all the same as the ones for backstroke and so on.**

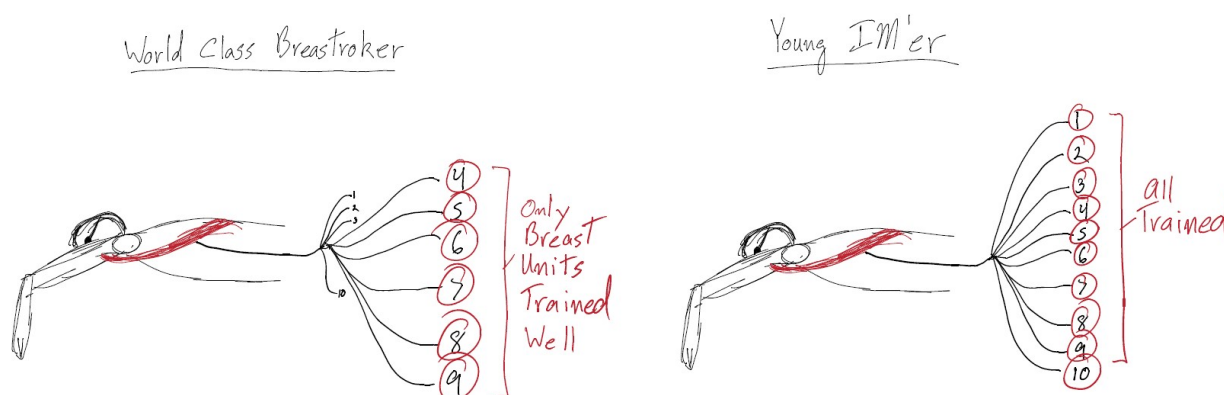


Yeah... there's some overlap (especially with free and fly) which will explain minor improvements in your times without training the other strokes, but from a training perspective it is good separate it out. If we pretend your lats were made up of 10 motor units, we would find that each stroke only fires 6 of them and **these 6 motor units won't be the same for each stroke**.



This is why butterflyers swim a lot of butterfly. There is just no way around it, if you want to get good at your stroke, you have to do it. **If you just swam freestyle, you'd be missing out on training some of your butterfly motor units** which means you won't reach your potential in that stroke. This applies to kicking too. Different motor units are used for free, fly, breast and backstroke kicking. That's why you need to train them all to have a good IM. Remember what we said earlier: what you don't train won't improve.

This also explains why older swimmers specialize (and I really mean OLDER...specializing young can have negative effects which we will discuss another time). As you get better and faster, it takes more time to train those same motor units to achieve the next level. Often times there just isn't enough time in the week to train everything at its maximum capacity, **so swimmers will focus on their best strokes and train those specific motor units very, very well.** This also explains why most world class swimmers can be beat in their off-strokes. Those "off-stroke" motor units never got trained as much, so they just won't function at the same level.



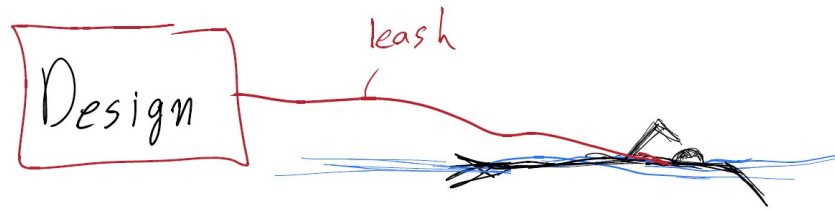
Tangent: We are not saying there is no benefit to doing other strokes. From a motor unit activation perspective, you will mostly be training what you are activating, everything else will not improve.

Unlocking your Nerve Potential

Ever wonder what would happen if you could activate all your motor units all at once? Ever hear of grandma picking up a car to save her grandchildren? Something like that would happen. So why can't you do that in a race? The simple answer is **your body holds itself back.**

WHY?!

We need to go fast right now, we have to beat our rival, this is for the championship title! Your body don't care about that stuff, plain and simple. Think back to a time when people lived on the fields and you didn't know when your next meal was coming. Do you want a body that is willy nilly with its energy? Do you want a body that will exhaust itself and damage its muscles every time you went on a "leisure" stroll? **Your body is designed to survive, and swimming a race is asking your body to spend on something that is not essential to survival.**

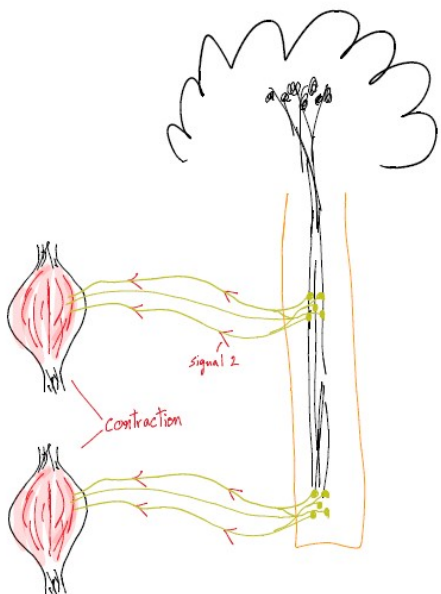


That may be the design, but it doesn't have to be the end of the story. Unlocking your body's potential is mostly a matter of sports psychology (BOS-III), but there are some things we can talk about here. Let's go back to grandma picking up a car...what happened? What changed to give her so much strength? That is a real hard question to answer by scientific ways because how would you run the experiment...hold a gun up to a swimmer's head, force them to swim all out sets and measure what changed in the their bodies?...bad idea. **So this is a lot of speculation, but here it goes.**

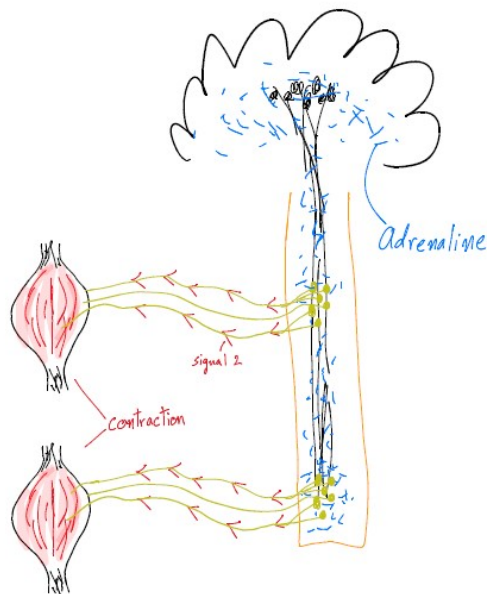


Adrenaline is a hormone most people know, and it is probably the answer to our questions. When released in large quantities during a "crisis" moment this hormone has one job...**keep you alive at all costs.** It "unlocks" the full muscle potential allowing for greater performance. It also does a number of other things to your heart and blood vessels to maintain that performance (Hormone chapter). But adrenaline doesn't really affect skeletal muscle directly, so the theory is that it "**unlocks**" nerves and allows a **bigger and better signal to be sent to your muscles.**

without Adrenaline

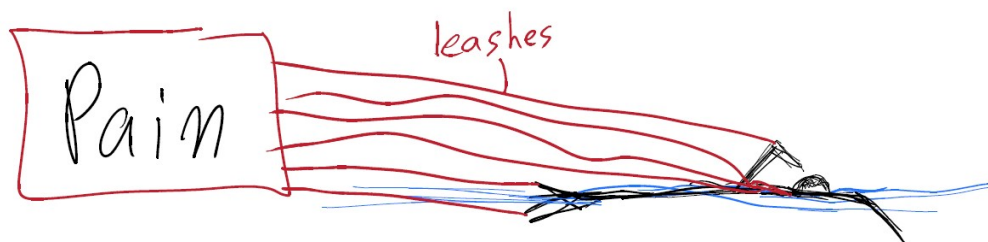


with Adrenaline



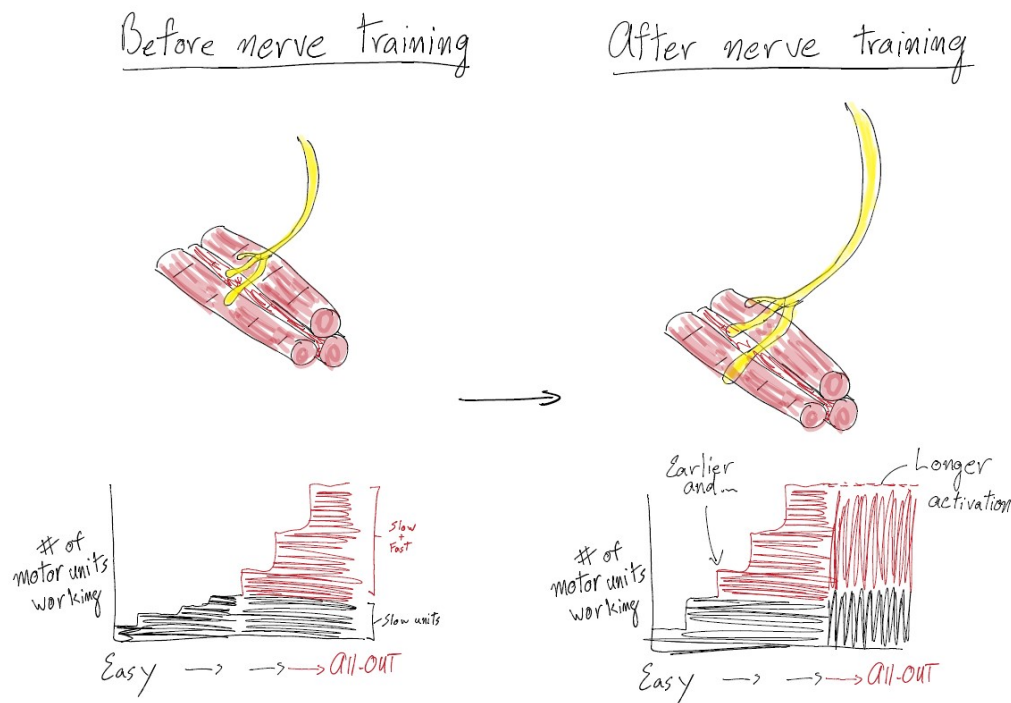
The nerves inside the spinal cord are under tight control by other nerves. Reflex nerves, upper motor neurons...so on. **The body is trying to limit the maximum potential of muscles so they don't just tear themselves apart.** Pain is another big inhibitor of motor unit activation. Ever had shoulder pain and try to swim all-out? No matter how motivated you are or how high your "pain tolerance" is, there just seems to be a block on how fast you can go. This is your body's protective mechanism, it gives pain the power to turn your muscles off. This is a good thing. You want to heal right? That means being patient and giving your body time.

Tangent: Pulled muscles are actual tears in the fibers. This happens when you fire too many motor units too quickly without training or warm-up or when you are too tired to control your body's movements. Most of the pain is due to the surrounding muscles spazzing out to limit you from moving that muscle anymore until it heals.



So, if your body has built in ways to keep your muscles in check and prevent them from reaching their full potential, is there a way to "unlock" that potential? To certain degree...Yeah! **Speed work, dryland, and weight lifting are all ways to "train" your nerves.** This type of training will: increase the

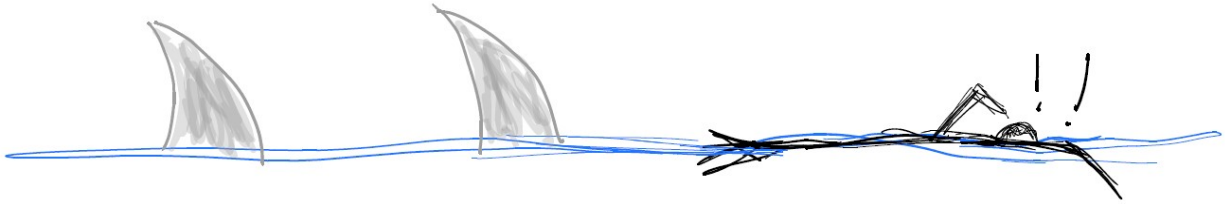
frequency of motor unit nerve firing (increasing muscle fiber contraction strength), synchronize motor unit firing (so they all turn on at the same time, instead of recruiting one by one), and better activate opposing muscle groups to stabilize joints and direct the power in a more meaningful way.



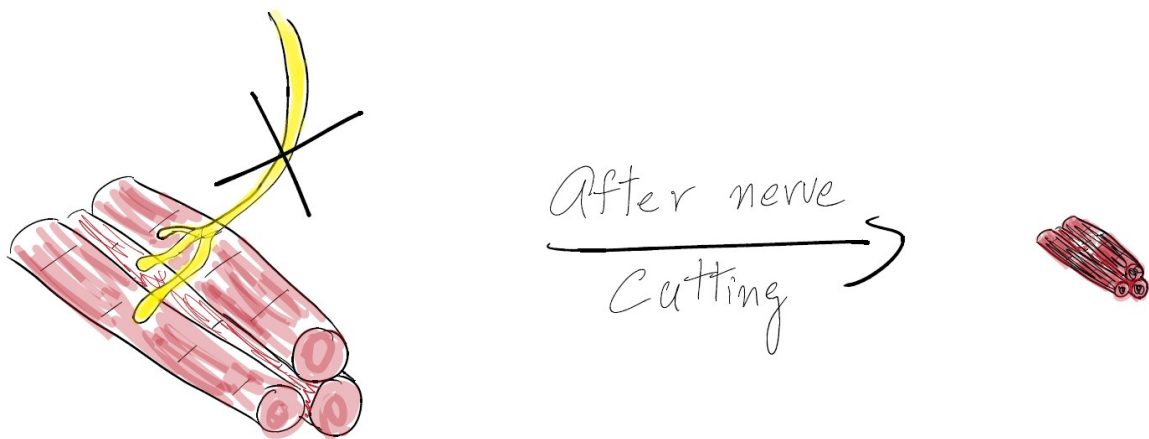
Another weird way we know nerves are responsible for holding us back is by looking at experiments done with hypnotized people. **Simply hypnotizing an athlete and making them believe they are faster or stronger than they really are will improve their performance!** The power of the mind can never be underestimated, that's why we are going to have a chapter on sports psychology later on.

Tangent: Funny story about hypnotized swimmers... rumor has it back in the 80s, the Russians had a great 200 flyer, but this swimmer couldn't control his race. He would go out way too fast and would not have enough reserves to come home fast. The team coaches and physiologists (fancy word for a person who studies how the body functions) tried to convince him he had to pace himself the first 100. But it never worked, and the flyer would just go out fast and die.

So, they decided to hypnotize the swimmer and make him believe that after the first 100, a shark would be chasing him. They figured this would give him the extra boost of energy he needed to finish the race. During his next race, the flyer does what he always did... out too fast. He hits the wall at the 100 and turns around. Half way down the pool, the swimmer stops, crosses over the lane lines, jumps out of the pool and runs screaming to the locker room! I guess the hypnotizing worked...kind of.



Just to show you how intertwined your nerves are to your muscles, if you trained only one side of your body (doing curls with just your right arm), then the other side would get stronger too! (not as much, but a pretty good amount). **The muscle fibers don't change, but just firing the nerves in a better way can change how strong you are.** On the opposite side of the spectrum, if you detach a nerve from the muscles, those fibers without a nerve signal will die.



Tangent: Bad carpal tunnel will do the same thing. By squishing and killing the "arms" of the nerves going into your wrist, the muscles of the thumb will stop getting signals from the nerves and eventually die.

So far, we have covered everything a swimmer needs to know about how muscles work, fuel themselves, organize in types and organize in motor units. Now it is time to look at how they take out the garbage.