

Why Muscle Matters & How to Build It

Perform with Dr. Andy Galpin · Episode 2 · June 19, 2024 · Transcript

Dr. Andy Galpin

The science and practice of enhancing human performance for sport, play, and life. Welcome to Perform. I'm Dr. Andy Galpin, a professor of kinesiology in the Center for Sport Performance at Cal State Fullerton. In the center, our mission is to conduct and disseminate research that enhances human performance.

In addition to my role as a scientist, I also work directly with high-performing athletes. This could include Olympic gold medalists, world champions, MVPs, Cy Young winners, all-stars across multiple sports, the NHL, NBA, the NFL, PGA TOUR, boxing, the UFC, and many more. So while I focus most of my career on sport and athletes specifically, my real passion is the physiology behind that. And so what I hope to share with you over this podcast is a deep dive into the physiology of human performance.

Now, that doesn't necessarily mean sports per se. This is really human performance at its finest, most broadest definition. This could be athletes, musicians, leaders, scientists, educators, or anything else in between. Human performance really is what you want your body to be capable of. So in order to accomplish that, I'm extremely excited to share with you the physiology behind human performance in a way that is engaging, applicable, and most importantly, useful.

Today, we're going to be talking about muscle, more specifically skeletal muscle, my favorite. Now, I know when you first hear that, your mind may jump to things like sport performance and big giant muscles and bodybuilding and aesthetics. And while that may or may not be of interest to you, I will tell you candidly it's a large interest of mine. You may be surprised to learn that muscle quality and quantity are incredibly important for your overall health and well-being.

Yeah, you heard that right. Quality muscle is essential for the vitality of nearly every cell, organ, or organ system in your entire body. Let me give you two specific examples of what I'm talking about. First is the connection between muscle and the brain. Now, there are many lines of evidence we could utilize here, but one that I think highlights the point beautifully is a recent study on about a half a million participants, mostly middle-aged men and women.

And in that they found that about 30% of dementia cases were directly attributable to low grip strength. Now, that may sound alarming and/or interesting to you, and I promise, we'll get into the details of that study, and many others, later in the show.

Now, that was an example of muscle quality or functionality. Let me give you another one

regarding muscle quantity or size, and how that will directly relate to longevity or lifespan. Once again, there's lots of research to pull from, and we'll get into this later in the show. But it's very clear that being under muscled is a significant problem.

In fact, we know this is such a big problem. The National Institute of Health has an entire wing dedicated specifically to sarcopenia, which is the advanced loss of muscle with age. If you'd like some hard numbers to wrap your head around a little bit here, consider this. Those in the bottom 20th percentile versus the top 20th percentile in terms of how much muscle mass you have on your entire body, well, those in the bottom portion have about two times the risk of all cause mortality as those in the top.

And so while we certainly are going to consider functionality or quality, most important, quantity matters a lot as well. So based upon what I've just shared, and more that we'll get into later in the show, to me, skeletal muscle is by far the most important organ in your entire body.

Now, in order to convince you of that, I'm going to start by telling you how it actually regulates performance across the entire system. This includes everything from its relationship to how long and how well you're going to live, to how it regulates your blood glucose, metabolism, and overall energy production, to other factors that you may or may not also be aware of.

After that, we'll get into what muscle actually is. How is the structure and the function of it determining how you move throughout the world? And then finally, we'll get into the assessment piece. How do you identify whether or not you have enough muscle. And if you don't, how do you go about improving that.

Now before we go too much further, I'd like to take a quick break and thank our sponsors because they make this show possible. Not only are they on this list because they offer great products and services, but because I actually personally love them and use them myself.

Today's episode is brought to you by Absolute Rest. Sleep is the bedrock of human performance, which is why I always focus on it with my elite athletes. But despite trying every wearable, and even sending people to full blown clinical testing in sleep labs, we rarely got very far. That's why two years ago, I co-founded Absolute Rest, which redefines what it means to be a high performance sleeper.

After tremendous success, we are now ready for our next challenge, a first of its kind sleep optimization program that combines advanced sleep technology with personalized coaching, all at a fraction of the cost of a traditional sleep study. The SleepLens program allows you to run a full, FDA-approved clinical-grade sleep study from your fingertip every single night.

Our team of sleep scientists then use your data to create personalized solutions that drive real

changes in your sleep. No more overnight stays in creepy sleep labs, no more wearables with questionable accuracy, and no more wondering if the changes you're making in your nightly routine, habits, or supplements are actually working or not.

If you'd like to try Absolute Rest, go to absoluterest.com/perform to secure your spot in the SleepLens program and save \$100. That's absoluterest.com/perform.

Today's episode is also brought to you by Momentous. Momentous makes safe, high quality supplements. Now, I naturally despise and frankly don't trust most supplement companies, and for good reason. In fact, I recently co-authored a review article that was published in 2023, in which we found that the amount of adulterations, which are accidental contaminants or deliberate spiking, like adding stimulants or anabolic or other agents, which are not supposed to be in the product, or mislabeling, is shockingly high.

They range from about 10% to 40% of all supplements, depending on the study that you pulled. So I actually honestly spent literally years vetting both Momentous and their leadership team before deciding to officially partner with them last year. Every single Momentous product is third-party tested, and that's expensive. And many are even further NSF-certified for sport.

But more unique than that is their vision for the future of where this, frankly, dysfunctional industry should go. On top of this strong ethical company value, their products are also fantastic. They're used by the best of the best, including countless professional teams, Olympic committees, 31 of the 32 NFL teams, many members of the Department of Defense, and many more.

They offer a range of products. For me, those are your creatine, vitamin D, and fish oils. Now, none of you have to use supplements. And I genuinely hope you never feel pressured to do so if you don't want to. However, they can be beneficial to some. So if you're going to use them, I strongly encourage choosing a brand like Momentous, which in my opinion, has the highest safety and quality standards in the world.

If you'd like to give Momentous a try, go to livemomentous.com/perform to get 20% off your order. Again, that's livemomentous.com/perform to get 20% off.

OK. So why do I think skeletal muscle is so special? Well, I want to break this into two parts. The first is the quantity of muscle you have, and the second is quality. Now the quantity of muscle, compared to other organ systems, say your immune system, your brain, central nervous system, or even your bones, skeletal muscle is the one you have the most control over with lifestyle factors.

So what I mean by that is it is the one you can manipulate the most to alter your physical

appearance. Now, you may want to look a certain way or not-- another way, that's entirely up to you. But skeletal muscle is the place you will go to determine that. Of course, you can reduce the amount of body fat you have overall with lifestyle, but it's hard to really pick that from a certain space or place on your body.

For example, if you wanted to lose fat on your triceps or the back of your arm or on your legs or so, it's really difficult to target the fat loss in that area. It tends to come globally, a little bit from everywhere in your body. But skeletal muscle is different. You can absolutely focus entirely on growing your calves, or on one arm relative to the other, or anything else you want to do.

So again, of all of the different organ systems and structures on your body, it is the one you have the most control over to determine how you look. That said, I want to focus more on the second part of our discussion here, which is the quality of the muscle, so the functionality, what it's providing to your body, and how it's helping you navigate through the world.

So remember, skeletal muscle is the direct interface with the world. I know folks that are in the neuroscience department, people like Andrew, love to give all the credit to the nervous system and the brain. And that's fine. Obviously, that's what's making the decisions. But skeletal muscle is the workhorse, so nothing will actually get accomplished without the skeletal muscle.

It's a little bit of a chicken and egg here, I get that. But in my opinion, nothing is going to happen in your body health wise or actual, again, interfacing with the world, without skeletal muscle. This is the workhorse of your life.

Now, before we go too much further, I want to back up just a touch. I realized I've described skeletal muscle as an organ system several times now, and many of you may not know what that means or why it matters. You see, if you would have gone on something like Jeopardy in 1990, and they asked a question of what's the biggest organ in your body, you would have probably said skin, and that would have been correct at the time.

However, hopefully Jeopardy has made a change. We realized that's not the correct answer. It is skeletal muscle by a landslide. So what it means to be an organ is that it secretes something and communicates to other parts of your body. And it wasn't really until the last 20 years where scientists have identified and realized that skeletal muscle is what we'd say, not stupid. In other words, we used to, again, neuroscientists think that skeletal muscle just is a one way street. Information comes in from the nervous system, tells muscle what to do, and then it executes.

What we now realize, skeletal muscle is far smarter than that. It is not only accepting information from the nervous system, also from the hormones, endocrine system, things that are in your blood and everywhere else. It's also sending signals back out. This includes things that are now

called exerkines. So these are cytokines, or again other information molecules, excreted from muscle, in this case, in response specifically to exercise.

And their direct target is other organ systems in the body. This would include the kidneys, liver, lungs, brain, and every other part of your system. There are also other molecules that we'll discuss later, such as non-coding mRNAs that are critical to your body, understanding its overall status. You see, really, the way that I think about it is skeletal muscle, given the fact that it occupies far more space in your body than anything else, is the primary key to physiology communication.

It is the biggest factor that is both receiving and extending information out to the rest of your body. So when you don't have enough of it, or it is compromised, you're going to see problems in every other area of your life. To double down on that statement, if you were to look across the literature on both skeletal muscle mass, as well as muscle quality, so think in this case, muscle power, muscle strength or something like that, you will see connections to basically every aspect of overall human health, and performance.

This is why, if you were to look into the scientific literature on everything from sport performance to all cause mortality, you'll see a strong tie to skeletal muscle quantity and quality. So, for example, skeletal muscle has been implicated in the regulation of numerous systems, which include, but are not limited to all cause morbidity and mortality, cardiovascular health, cognitive health, brain health, mood, inflammation, immunity, fertility, metabolic health, hormone health, bone health, and much more.

Another important thing to realize is that most of your metabolism in your body is actually occurring in your skeletal muscle. In fact, because of this, around 85% or so of the heat you generate in your body is coming from skeletal muscle. It's also the primary place in which you dispose of and regulate blood glucose, which is important for both short-term performance, as well as long-term health.

In fact, recent research has shown that athletes are up to 25% more effective at disposing glucose into their muscle than non-athletes. So regardless of how you're defining human performance, whether that be hit a golf ball 300 yards, fix your low back pain, have more focus at work, or alter how you physically appear, skeletal muscle is going to be at the center of that conversation.

So how much can it really change? Let's talk about the adaptability, or what we call plasticity of skeletal muscle. In my opinion, I judge the overall quality of skeletal muscle in three main areas. Effectively, you can think of these three as look good, feel good, and play good.

What that means for everyone? The first one is pretty obvious. It should look how you want it to look. And that's going to be different for everyone. People want different sizes and shapes. Some folks want more size in certain muscles and muscle groups and less in others. That's entirely up to you.

The second one, feel good. This should be resilient and non-sensitive. So you should be able to engage in multiple types of metabolic processes. You should be able to handle multiple types of contractions and multiple ranges of motion, et cetera. So again, we want resilient muscle that can do many things basically on demand.

The last one then is play good. Can we execute on the things we're asking it to do? So can it go fast when we want it to go fast? Can it go under control when we want it to be under control? Can it be high precision? Can it be gross movement? And can it respond and recover quickly?

So as we continue on this discussion, I'm going to have all three of those goals in mind that really, at the end of the day, it should look a certain way. It should be resilient to be able to do many things in many areas, but then also be able to execute the exact way that you personally want it to execute.

As a quick example, when we say smooth muscle, think about the tiny muscles involved in digestion, moving food throughout your digestive tract, stuff that is really not under your voluntary control, not really going to respond and change, say growing in size, increasing in strength in response to a workout or lifestyle interventions. It's the stuff that moves your life beyond your somatic or cognitive control.

Now, in terms of cardiac, we're really basically talking about one thing, and that's your heart. There's a few other things that go along with that, but that's basically what we're talking about. Skeletal muscle is almost everything else. So it is your biceps muscles, your hamstring muscles, your quadriceps, the things that you have both voluntary and involuntary control over. They tend to be large muscles, but they can be the small ones as well.

Think of your intercostals the muscles between your ribs that are contracted to expand your chest so that you can breathe and bring volume into your lungs. The small muscles in your eye that control fine motor movement, and everything else like that. So to recap, smooth muscle is the stuff you have very little control over, tends to be the muscles necessary to keep you alive for digestion and breathing and things like that.

Cardiac is effectively your heart. And then skeletal muscle is basically everything else. It's the stuff that relegates human movement. You have both control and involuntary control of it. They can be large muscles or small muscles, but once again, it's basically everything non-smooth and

non-cardiac.

Now, if you listen to any of doctor Andrew Huberman's work, he's talked extensively about the role of neuroplasticity, which is the ability of your nervous system to adapt or change in response to various stimuli or lack thereof. Well, skeletal muscle's ability to respond like that is even greater.

So it will change its nature in both the short term. And now we're talking in the order of seconds to minutes, as well as in the long term. So its ability to alter how you feel and perform is extensive. In order to understand that, we need to talk briefly about what muscle really is. So what exactly is skeletal muscle?

Well, let's start all the way back at the beginning. In your body, you've got somewhere between 600 to 700 different muscles. Now, we don't know the exact number. There's no scientific consensus on that. In fact, I remember fairly recently, a paper came out arguing for the identification of a fifth quadricep muscle. So the tradition is that you've got four, hence quadricep muscles in your quad or your thigh there. And they had argued that they had identified a fifth one.

Now, I don't know the literature on that as well anymore. But the point is, you've got a large number of muscles throughout your entire body. We tend to group them into muscle groups. So continuing with the quadriceps theme, we tend to call that the quad muscles, although that is actually four individual muscles.

Your biceps are actually a combination of several different biceps muscles, your triceps, et cetera, et cetera. And so we've got all the muscles in our body. We've got these subgrouping of muscle groups. And then within each individual muscle, you have hundreds of thousands of muscle fibers.

Think of this like a ponytail. So while you'd call that ponytail one thing, it's actually just comprised of thousands of different individual hairs. So when we want to talk about the individual hair, we say hair follicle. We want to talk about the ponytails unit, we say the ponytail.

So the same thing would happen. I could talk about your hamstring muscles, but really, am I talking about one muscle that say the semimembranosus or semitendinosus, the hamstrings as a group, or the individual fibers within each of those individual muscles?

So drilling down on that, if you can imagine going back to the ponytail, there is a layer of connective tissue or fascia that surrounds each of these muscle fibers that holds them together. But that's what actually collectively makes them one unit, and why we call that a muscle. That muscle is then wrapped around further with more connective tissue.

All that comes together to form a tendon. That tendon then connects to the bone, such that when you activate or contract any of those muscle fibers, it contracts the muscle as a whole, tends to contract the entire muscle group. That entire muscle group comes together, goes into a tendon. That tendon then pulls the bone.

So the easy example, again, sticking with the quads is an easy thing. You contract any muscle fibers within, say, the vastus lateralis, the muscle that is on the far outside of your leg. That is one of the quadriceps muscles. The entire quad tends to feel like it's contracting. That then goes over through the patellar tendon.

The patellar tendon inserts on the front of the lower leg bone, which causes the lower leg bone to lift up, and for your lower leg to extend. That quickly is how muscles work and how they actually cause human movement. It's through one, the activation of the muscle, two, the contraction of the muscle, and then three, the muscle pulling on connective tissue, which makes bones move.

Now, the amount of muscle fibers you've got in each muscle varies pretty highly. And it's somewhere in the neighborhood of 1 to 300,000 individual fibers. Interestingly, this number will double during the first few months of your life, and then basically stabilized by the time you reach adulthood.

Now, as I mentioned, you've got somewhere between 100,000 and 300,000 fibers per muscle. One example, the biceps brachii has been shown to have about 250,000 muscle fibers. And so if you ran some quick math there, that would mean most of us probably have somewhere in the neighborhood of between 125 to 250 million muscle fibers throughout our entire body.

And these fibers are extraordinarily unique in all of biology for a couple of reasons. Number one, they are absolutely huge. They are some of the biggest cells by volume in all of biology. It is common to have a muscle fiber that is up to 2 to 3 centimeters long, and in fact, many have been shown to be up to 10 centimeters or so long.

Think about the sartorius muscle, this muscle that goes from the inside of your hip bone, that front side there, and goes all the way the inside of your knee. It is theorized, and some folks will say in physiology lore that you can have a single muscle fiber that runs the entire length of that. I don't actually know whether or not that's true, but it would not be rare to see a fiber that is, again, four to five to up to six inches long, which is enormous.

In terms of the width, same kind of idea. You'll see these things as extremely large, somewhere between four to five micrometers in terms of cross-sectional area, micrometer squared. To give you a little bit of concept of how big that is, number one, you can see that with the naked eye I

could pull up in my laboratory a pair of tweezers, a single muscle fiber from a human. I could hold it up right now. And on this camera, you would absolutely be able to see that, both on camera, as well as with your naked eye if you were within even 5 to 10 feet of me.

In terms of cross-sectional area, you're looking at something like four to five micrometers squared, which a little bit of context there, one time actually, I had a long established power lifter, as well as anabolic steroid user in my Lab, and we biopsied this individual. And his muscle fibers were closer to 9,000. And the closest equivalent we found there was actually a rhinoceros.

So muscle fibers are not only large in terms of biology, but they ability to gain size is extraordinary. As again, I said earlier, one of the things that makes skeletal muscle in humans, especially unique is the ability to respond and adapt based on stimuli.

In fact, it seems to be quite unending. Now we'll come back and talk about muscle fibers, size, and how to develop it a little bit later, but getting back to this idea of fiber number. As I mentioned, it's thought to be fairly fixed once you reach adulthood. However, it is extremely clear that this number will go down with aging unless you do something proactively to prevent that. It's actually also very clear that this number can increase with anabolic steroid use.

Now, this concept of growing new muscle fibers is called hyperplasia, and something that has been hotly contested in the exercise physiology world for many, many decades. Now, I will give you a little bit of a behind the scenes here. I personally am always been a big believer in hyperplasia happening. I won't say the science is strongly in my support, but it's one of the passion projects that I'm not going to give up on. OK.

Now what I'm really talking about here is there's no question whatsoever that new cells can grow. That's not really the debate. What is up for discussion, though, is whether or not that happens as a normal response to normal training in healthy humans. There is strong evidence that anabolic steroid use, especially over a number of years, can increase that number. And again, we know it will decrease with aging.

Now when I say anabolic steroid use, I'm mostly talking about testosterone here. Now please, so I can be ultra clear here, I'm not encouraging anyone to utilize antibiotics steroids or testosterone. I'm not a medical doctor. If you are interested in any use of exogenous hormones, that's something you need to work out with your personal physician.

This is not, again, me encouraging or recommending the use. I will not also suggest it will make your muscle healthier or any better. There are many factors to think about when considering exogenous hormones. And I am not the person to take advice from on those things.

We also know that consistent strength training will prevent the loss of those muscle fibers over

time. Whether or not you can, again, go above and beyond your normal set at a normal age with just basic strength training, I guess is still up for debate. There are maybe some things if you catch me off camera, I'm willing to share with you. But according to the current science right now, that's the best we can say.

So what this means is you've got two paths to changing skeletal muscle structure and function. The first is increasing the amount of muscle fibers. As we just got done discussing, that's quite challenging to do in normal settings. And so I want to spend more of our time talking about how do we alter the metabolic and contractile properties. So another thing that makes skeletal muscle extremely unique is the fact that it is multinucleated.

So now remember, the nucleus of the cell is what holds your DNA. It delegates all activities and tells the cell to grow, shrink, die, repair, or any other necessary function. The overwhelming majority of cells in all of biology are single-nucleated. Some of them actually get very interesting when they have two or three, but skeletal muscle has thousands per cell.

This allows it to actually have such extreme size because now we have more delegation centers throughout it. I can give you an analogy here. Let's imagine you're running a business and you want to have a branch manager at every one of your offices. Well, if you only have one branch manager, it's hard to have an office in, say, Chicago, New York, Dallas and Seattle.

Too many little things happen in the local areas. It's hard to delegate and to change things quickly. But if you could put a manager in every single location, the success of each branch, as well as the speed and turnover goes up. That's effectively what your muscle cells are doing. They're putting a lot of nuclei in a lot of different places. So it allows not only the size to expand, but where this really matters is the adaptability.

Your muscle is hyper responsive to things that are happening in a short time window across a broad domain of insults. What I mean, this could be responsive to physical contraction, to blood flow, nutrient availability, glucose, oxygen, hormones, lifestyle factors. All of these things are being measured and monitored by skeletal muscle. And because it has the ability to adapt in multiple segments, it can do that. And it can do that very quickly.

Giving you some firm numbers on those nuclei, let's say that biceps brachii muscle we talked about a second ago was 10 centimeters long. It may have something in the neighborhood of 3,000 nuclei. If you were to then count up all the muscle fibers in total, this would mean you would have in the ballpark of 750 million nuclei in the entire biceps muscle.

You extend this out to all 600 plus of your muscles, and that puts you somewhere in the neighborhood of around 500 billion nuclei throughout your entire body. That's how responsive

and adaptive skeletal muscle is to everything you're doing in your life. We're going to talk a lot more about these myonuclei in future episodes because, as I mentioned, they are the primary place that are going to regulate how your muscle cells respond and change to external stressors.

But what regulates the contractile and metabolic properties? That's actually something different. And it's what we call the muscle fiber type. You've probably heard of this referred to as a fast twitch or slow twitch muscle fibers, but it actually extends beyond that. Now on the surface, that's a fine, broad explanation, but we can go a little bit past that, and I think it's helpful to do so without being unnecessarily exhaustive.

Really, fibers can be classified as the following, slow Twitch, or another way to say that is type 1. And then your fast twitch fibers are broken down into two major categories, your type 2A, as well as your 2X fibers. Many of the properties are the same between all these fiber types the microanatomy, how they're designed, all the things we've talked about, how they're wrapped in connective tissue, their nucleation status, et cetera, et cetera.

The properties that are really distinct are again, the contractile and metabolic ones. Slow twitch fibers tend to be, but are not always smaller. In fact, in endurance-trained individuals, they can oftentimes be larger than fast twitch fibers. But their contraction is exactly that, the twitch or the speed of contraction is slower. It doesn't necessarily mean the strength or force behind contraction is smaller or less, it's just that it contracts a little bit slower.

The advantage, though, is they tend to be highly fatigue resistant. They are better at utilizing fat as a fuel source. They have more mitochondria. And their overall good at what we call anti-gravity or postural. So when you think about slow twitch fibers, they tend to be the ones that are on all day, keep you upright and erect, keep you moving, and keep you at a low level of contraction, but continuously.

Fast twitch fibers, particularly the 2A fibers, are really the opposite. So they're going to be hedged more towards fast speed of contraction. But really, they're not particularly effective at fatigue resistance. They are going to prefer using things like phosphocreatine or carbohydrates as a fuel source, and are not as effective at things like fat or long term sustained contractions.

The third and final type 2X are the fastest of the bunch. While your 2A and fast twitch fibers are somewhere in the neighborhood of five to six times more powerful than a slower type 1 fiber, a two fiber is in the neighborhood of 20 times more powerful. The downside is we don't really have any good evidence of normal humans having many, if any, pure 2X fibers.

Oddly enough, we see it in extreme muscle disuse situations. Things like spinal cord injury or coming back from extended spaceflight or situations like that. And so there's a lot of mystery still

behind these 2X fibers. We could get into that, again, maybe more detail a little bit later.

So on its surface, while we really have these three distinct unique fiber types type 1, type 2A, and type 2X, it is really appropriate to discuss basically the type I and type 2A's from now on. Now within any individual muscle you have on your body, the proportion of fast twitch to slow twitch, in other words, the amount of fast or slow twitch fibers in that muscle, varies widely from muscle to muscle, as well as from human to human.

Now, that actually determines a lot about the function of that muscle. For example, if you take, say, the soleus muscle, which is one of the small muscles kind of behind the back of your calf there, that goes into the bottom of your heel that is heavily based toward slow twitch muscle fibers.

Depending on the person, it would be something in the neighborhood of 70% to all the way up to 90 plus percent slow twitch fibers. And that's because the primary purpose of the soleus is to keep you standing and moving all day. It's not meant for explosive power, or sprinting or jumping or anything like that.

If you were to compare that to the other major muscle in your calf, the gastrocnemius, that's almost the exact opposite. And a lot of folks, it is, 60% plus to 70% or 80% fast twitch fibers. So the gastroc is there for the exact opposite. It is there for the explosion, for the jumping and sprinting, and not necessarily to keep you upright all day.

Now, that's not necessarily true of other animals. In fact, this is one of the things that makes examining research in this area important to pay attention to, whether you're looking at a study from a rat or a mouse, a cat, a bear, or any other animal. Is that it's different. In fact, mice, the soleus is almost exclusively, if not, 100% slow twitch, and other muscles like the plantaris might be the opposite, 100% fast twitch.

And so while there's clearly important information we can gather, there is not necessarily a direct and equal comparator. So as I mentioned, the amount of fast twitch and slow twitch, the fiber proportions in the muscle groups varies within your own body. It also varies from person to person.

So if I were to biopsy myself, as I have several dozen times, I would know and see that say, in my vastus lateralis, the muscle on the outside, which is the most common muscle to biopsy for a number of reasons, it has the least amount of nerve innervations. There's no major blood vessels flowing through there. It's easy to access. It tends to be quite large. I don't have to go past any other muscle groups, et cetera, et cetera.

So within that muscle, I have seen people in my laboratory as high as 90% plus slow twitch, as

well as up to 85% fast twitch, and everywhere in between. And so the quadricep, again, the VL, specifically here, is meant to really be responsive to training. And we'll talk about this more later.

Other muscles like the soleus, spinal erectors, other muscles, say, in your fingers or eyes are not necessarily going to change as much. It would be very difficult to convert your soleus into an exclusive, fast twitch muscle fiber, because it's really meant to do one job. And the overall stimuli that you provide to it is fairly similar.

It doesn't really matter what kind of exercise or training intervention you put, how many plyometrics or sprints you do, the vast majority of the time that your soleus is contracting, it's still because you're standing. And so there's just not a lot of change that can happen there.

The VL is quite different. Since it is so important in all knee extension and really hip movement, it's going to be hyper responsive to what you're asking it to do. So again, it can vary heavily within your body, as well as from person to person. And we'll talk about more of this stuff later. But as you've already heard me allude to, your fiber type, again, the proportion of fast and slow twitch, is hyper responsive to lifestyle.

We know extensively, for decades now, that it will respond to both, changes in exercise, as well as the removal of that. So some of the classic Dallas bed rest studies, where they put people into bed, where their head was something like six degrees below their legs. So you can imagine laying on a bed with a slight backwards tilt so your head is a little bit below, your feet are a little bit above.

And we've done this for up to 50 plus days. And what we're doing there is trying to simulate both spaceflight. This was initially done in preparation for thinking humans were going to go to the moon or further for extended time, as well as it's actually represents a nice model of aging. You can actually simulate upwards of a decade of aging in about 10 days of bed rest or so.

And so we get a really good grasp of what happens when you go into disuse. Similar for if you have to go into a cast, post-surgery, or something like that. So we see in those models of-- in that forced inactivity, as well as any number of exercise training studies, looking simply at individuals cross-sectionally, so those that have exercised for long periods of time throughout their life, compared to those who haven't, any of these interventions you want to look at. And we see responsiveness in your fiber type, profile based upon your physical activity.

Other interventions that are less well understood, but are also actually quite interesting that we will discuss in depth later, things like nutraceuticals, vitamins, minerals, phytochemicals have been shown to alter fiber type in extreme concentrations. Now, whether or not small changes in your diet, say, how much carbohydrates or protein you're eating or any supplementation, can

actually reach concentrations high enough to alter fiber type is yet to be determined.

I'm not really aware of any research showing that, but certainly, we have seen that in many models, again, where we can give them non-physiological doses. But even stuff as well as hyperbaric or extensive oxygen concentrations, alterations in CO2 intake, and things like that, have also, again, mostly in animal models shown to alter fiber type.

So whether or not this actually happens in a normal human circumstance is not as relevant right now, but it's just highlighting the concept of how responsive this muscle is to everything you're doing in your life.

I'd like to take a quick break and thank our sponsors. Today's episode is brought to you by David. David makes protein bars unlike anything I've ever encountered. They have an amazing 28 grams of protein, only 150 calories, and 0 grams of sugar. That's right, 28 grams of protein. And 75% of its calories come from protein. This is 50% higher than the next closest protein bar.

Honestly, it's the best tasting protein bar I've ever had in my life by a mile. Now, I don't usually talk about products before their launch, but these bars by David represent a meaningful breakthrough in both macronutrients and taste. And when you guys try it, you will know what I mean.

After lots of research and development, these David protein bars are releasing to the public. In September of 2024. The macronutrients one more time are 28 grams of protein, 150 calories, and 0 grams of sugar. And they do this with excellent ingredients. If you're interested in trying these bars for yourself, you can go to davidprotein.com/perform to purchase if possible, or be notified when they're available. Again, that's davidprotein.com/perform to purchase if possible, or be notified when they are available.

Today's episode is also brought to you by AG1. AG1 is a foundational nutrition greens supplement. That means AG1 provides a variety of vitamins, minerals, probiotics, prebiotics, and adaptogens in an easy to drink greens powder. Initially, I was very skeptical of AG1, as I am with all supplement companies, frankly.

But after months of discussions with their lead nutrition scientists and the team at AG1, I've been impressed by their commitment to sourcing the highest quality ingredients and rigorous testing to ensure that every single batch is free of banned substances, allergens, heavy metals, microbes, pesticides, herbicides, residual solvents and mycotoxins.

It's even earned the prestigious NSF-certified for sport third-party testing approval. Now, AG1 is not a replacement for eating Whole Foods, but it is a great way to fill in the gaps. And it's been a big help pushing some of my clients just in the right direction for eating more high quality foods

because it helps them with cravings, digestion, and many other benefits.

Now, not everyone needs to consume Greens powders, but if you're going to do so, you better make sure it actually includes the ingredients that it claims to, and that those ingredients are of the best sourcing. If you'd like to try AG1, you can go to drinkag1.com/perform to receive five free travel packs, plus a year's supply of vitamin D3 plus K2. Again, that's drinkag1.com/perform to receive five free travel packs, plus a year's supply of vitamin D3 plus K2.

So in my opinion, the key take home is that things like your fiber type, again, which regulate the contractile nature, how fast and powerful your muscle fibers contract, as well as their metabolic properties, how effective they are at using fats and carbohydrates as a fuel source, how efficient they are at bringing in nourishment and getting out waste products, much of this is regulated by its fiber type. And your fiber type in general is responsive to changes in activity.

Now, if we were to have to compare the responsiveness of the fast twitch fibers to the slow twitch fibers, it is very clear. Fast twitch fibers are more reactive to things like physical activity changes. Whether or not you can increase or decrease the amount of slow twitch fibers in response to exercise, I think that evidence is clear, but it is of a much smaller magnitude than the plasticity within the fast twitch fibers.

Now, why that's critical then, is unless you do something about it from an exercise perspective, you're going to lose many of your fast twitch fibers as you age. A really nice example of this, a paper published in the last few weeks looked at lifelong strength trainers.

Now, this is interesting because while we are just starting to get data on lifelong exercisers, almost all how that has been in aerobic or endurance-based exercisers. We're just starting to come on board with these lifelong strength trainers. And what that paper found was that that activity to strength training, basically, over your entire life, was able to preserve fast twitch fiber concentrations. However, the endurance training was not.

And so as not to say that strength training is more important or better for your health at all, but it is simply saying, these fiber types are lost. You're not able to get them back, but you can preserve that or ameliorate that loss by chronic strength training.

Now, you're going to care about these fast twitch fibers for a couple of reasons. While we will acknowledge that both fast and slow fibers are critically important for overall muscle health, what makes fast twitch fibers unique is a few things. The first is that, again, they express the greatest capacity for force and power production. This is obviously critically important for young folks trying to enhance their clubhead speed on their driver when they're playing golf, or individuals as they move throughout age.

Think about scenarios in which you need to move your foot in front of you to catch yourself from a fall. You want to be explosive enough to go upstairs without fatiguing you. You need to have power to lift something up overhead quickly before it collapses back down, or any number of reasons in which you need to have strength and power as you age.

Now, the way that you regulate force production extends beyond just what the muscle fibers themselves can do. Unfortunately, I've got to get a little bit of credit back to the neuroscientist folks here, because really, this is a combination of nervous system, as well as muscle fiber characteristics. All of your muscle fibers are combined into what are called motor units.

So the definition of a motor unit is the motor nerve, as well as all the muscle fibers within that package. Now all of those fibers within that motor unit will be of the same fiber type, so fast twitch or slow twitch. And they're not necessarily laying next to each other in the muscle. They are spread out both superior and inferior. They're deep within the muscle belly. They're kind of all spread out.

And this allows you to control and not have spastic movement. So when you activate a motor unit, not only does this contract all of the muscle fibers in that unit, it contracts them all fully. That's called all or none principle. And so when you flip the switch and turn on that motor unit, you pass that activation threshold, it activates and contracts all the muscle fibers in that unit to their fullest potential.

And what you can't do is turn a muscle fiber itself on at 60% or 70% or 80%. So the only way you relegate force production across an entire movement is to actually turn on or off more or less motor units. The example here, say, I would like to take my hand and reach it up towards my eyeball and lightly touch my eye. Now I recognize and realize this is only going to take a small amount of force to move the weight necessary to move my hand to lightly touch my eye.

If I were to do that too hard, I would smash my finger into my eyeball and that would hurt. And so what I do is I start with what are called low threshold motor units. So these are motor units that are very susceptible to firing or contracting. And they activate, in this case, very slow and metabolically efficient muscle fibers, the type 1 muscle fibers.

And so what it says is I kind of start with the least amount possible. Physiology is very lazy like this. And so I'll start with the least amount of force necessary. And this allows me to move very slowly, but with a lot amount of control. And now if I realize that actually I had a 5-pound weight attached to my wrist, and I had to lift my hand with more force than I thought I needed, I would turn on more and more motor units.

And if I realized that I had that 5-pound weight, and then I added a 10-pound ball to my hand,

and I need more and more force production, I would slowly turn on more and more motor units. As we continue up this cascade, again, the size principle is telling us we start with the lowest threshold, smallest motor units. So this is not only tends to be slow twitch muscle fibers, but it's also, oftentimes, but not always, motor units that have less muscle fibers in them.

The amount of muscle fibers in a motor unit can vary highly. Several of them in your eye can be as low as a couple of dozen muscle fibers in the motor unit. And those in your glutes might be several thousand muscle fibers. So even if I activated one motor unit in my eye, I would get a small amount of force. One motor unit in my glute might produce hundreds, if not, higher amount of force per motor unit because I have more muscle fibers in that.

In addition, the muscle fibers might be of larger size than the glute and smaller size in the eye because we need more motor control there and less force production. Something like the eye, again, is meant to be highly precise with its movement, very low margin of error. I don't need to get there particularly hard. I need to get there sort of quickly, but I need to be under control.

The glute in this example, this is your butt muscle, one of your large butt muscles, they don't necessarily need to have a lot of fine tuned precision with the movement. They just need to contract a lot of force. And so the way that these motor units is set up is in large part determinant of how they produce force. And then again, what the function of that muscle actually is.

So to go back to what we were talking about a second ago, if I'm trying to produce this finger into my eyeball and I need to produce more and more force, I slowly activate more motor units. If I've realized the point where I need more force beyond that, I will increase and start activating the higher threshold motor units that also now start to tend to be faster twitch motor units.

And if I need extreme amounts of force, I will activate the highest threshold, which are the highest, and probably where we're going to get into our type 2X fibers, if we have any of them at all. And so what happens is, if we're playing the story backwards, is any movement at all in a muscle almost always includes the slow twitch motor units. But only when I start demanding high force production do I activate and engage the fast twitch muscle fibers.

If I then go weeks, months, years, or decades without doing anything of high force, those motor units just never get activated. Eventually, what can happen is denervation, which means the nerve stops attaching to the muscle fibers. Many of the muscle fibers die off. We talked about that earlier, the amount of muscle fibers in a muscle reduces with aging, if you don't do anything about it.

And then also, we see changes in motor units. So not only is our ability to produce force go down, but our motor control goes down because we've lost the amount of motor units going into

a muscle. Sometimes we can see what happens called muscle fiber type grouping. And so we'll see a nerve innervation, an axon that is gone, if you will.

The muscle fibers are still viable. And so a neighboring, motor unit will actually obtain them. And if they were, say, a fast twitch muscle fiber, but now they're in a slow twitch motor unit, they will convert that fiber type over to slow. And so you see these big patches or groupings of slow fibers, as opposed to them being spread out throughout the muscle, which reduces our motor control, and smoothness and muscle contraction.

So going back to our original point here, it's incredibly important that we do something to preserve our fast twitch fibers, because if we don't, we're going to lose them. And that then becomes extraordinarily difficult to bring them back, especially once we've lost the fiber number.

Returning muscle function, say your strength is actually very manageable through aging. But increasing the amount of muscle fibers as we age is very difficult. So once we lose them, they're basically gone for life. Before we go any further, let's quickly go back and recap what we've talked about. The importance of skeletal muscle extends far beyond sport performance or aesthetics.

In fact, it's important for a number of physiological factors across basically every organ system in your body. We also know that skeletal muscle is uniquely responsive to changes in the external environment. It is hyper adaptable to things like changes in physical activity, nutrition, or various other lifestyle factors. In fact, what I would call the superpower of skeletal muscle is its ability to respond and adapt both quickly, as well as permanently.

We talked about how the muscles, fibers themselves are multinucleated, which allows them that extended adaptability, as well as come in various forms, fast twitch and slow twitch fibers. The fast twitch fibers being more difficult to preserve and probably require some sort of steady and consistent exposure to high force demands over the course of your life in order to maintain.

So what I'd like to do now is walk through the three I's, investigate, interpret, and intervene for both muscle quality and muscle quantity. And I want to do them separately. And that's because while there is a giant overlap between the two, they are independent factors. Let me give you an example.

While there is a clear relationship between muscle size and muscle strength, such that generally bigger muscles are generally stronger, that's not necessarily always the case. We can see a number of examples here. Take any sport that is a weight class-based sport, wrestling, boxing, weightlifting, powerlifting.

Generally, the best of the best will increase their performance, in this case, say strength as

muscle size goes up. So clearly, there is a relationship between if you have more muscle mass, you potentially have the ability to create more force. But that said, if you walked out to the general population, or even in athletes, just because you find an athlete who has more muscle, that doesn't necessarily mean they're going to be stronger.

So again, there's a clear relationship here, but it is not necessarily one to one. In addition, it's incredibly clear and simple to increase strength or power without necessarily changing muscle size at all. These are all protocols we will go over and discuss at the end of our episode today. But there's a relationship here. In fact, I think a really nice way to highlight this even further is a recent publication of mine.

Now, this was led by a colleague of mine, Tommy Wood, a neuroscientist at the University of Washington. And what we did is we went into the national database. This is what's referred to as NHANES. So this is a giant national database of a study that they run every single year. They collect a bunch of data from participants. They put them into these big open source pools. And they may do IQ testing, strength testing, blood work, et cetera, et cetera. And scientists can come in and use these for any purpose.

Now, they've been running NHANES for several decades. And so you have many, many, many years of analysis that you can go back into and poke around in. Well, Tommy and myself and the rest of our team did that. And in our paper, we found a couple of interesting things here. Within the population of participants that we analyzed, there was no relationship whatsoever between their physical strength and their muscle mass.

In fact, there was also no relationship at all between their amount of muscle mass they had and their physical activity background. What this tells us is in this population alone, they accrued their muscle mass from non-exercise pathways. What we did actually find was a strong relationship between muscle strength and cognitive function. But that's something we'll talk about in a further episode.

So my point here is when you look at the relationship between, again, muscle mass and strength, they can overlap. They can also not. We can see further evidence of this when we look at things like mitochondrial health, testosterone concentrations, range of motion. A lot of these things are somewhat linked to muscle size, but not necessarily. In the last example, think about this as if you were to take somebody who has more muscle mass, that will tell you actually very little about their range of motion or flexibility.

If that extends to a certain point, of course, excessive amounts of muscle mass may start contributing. And so again, there's an overlap there. But there's so much distinction between the two. I think it's important that we actually treat them as almost separate variables. We're going to

start off with muscle quantity or muscle size. The gold standard here in research would be to use something like an MRI or an ultrasound to get a high resolution cross-sectional image of an individual muscle or muscle groups.

Think again the quadriceps, hamstring muscles, elbow flexors, et cetera, et cetera. The benefit of this, of course, is high fidelity accuracy and precision. The downside is it's really only telling you about that individual muscle or muscle group. It's really only covering that portion of it. So where the MRI is shot, it may necessarily cover, say, the part of the quadricep that's close to your hip or close to your knee if the MRI was taken at, say, the midpoint of it.

It doesn't really allow you to access or compare the right leg to the left leg, unless you also image that leg. And then really, from this conversation, the most challenging part about that is it is extremely unrealistic for most people to do. This would cost you a ton of money and be very challenging to get access to. So it's not a real viable solution for most people.

That said, new technologies are coming online. There are companies like Springbok, which allow you to do exactly what I just talked about. So this is a full body MRI. And this is quite different than using something to say, scan for early cancer diagnosis or something like that. This is really for the assessment of muscle quantity.

And so you can go into an MRI. It takes about an hour or so. And they will be able to capture an image, each individual muscle you have in your body, and give you a visual in three-dimension feedback of the muscle volume of them, which, again, allows you to compare, say, all the muscles in your rotator cuff to each other, compare the one on the right side, the left side, front, side to back, side, et cetera, et cetera.

These are available throughout at least America right now in a number of MRI facilities. It is quite expensive still for the average consumer, and it's not usable and available again worldwide. So if you wanted though to go after a gold standard, that would probably be your best bet.

If that's not available, or you're more interested in something that can be used anywhere, you have a couple of other options. And those would be things like your appendicular muscle mass measurement or your fat-free mass. Now, both of those metrics can be used to create what's called an index. In a second here, I'm going to tell you what some of those standard numbers are. And those are widely available based on your age or sex to be able to get an idea of where you should be at on those scales.

But quickly, when I say appendicular, what I'm talking about is basically how much muscle do you have in the appendices? So your arms and legs. That differs from your fat-free mass index. And it's important for me to point out, that's not necessarily representative of your total amount of

skeletal muscle. That actually can be measured in other ways. And would be a separate idea.

So what I mean by that is when you think about your body, if you want to globally say, OK, we're going to bucket everything into the amount of fat I have and the amount of non-fat I have. That's not necessarily only muscle. It includes things like water, muscle glycogen, bone, minerals, and things like that.

And so it's actually a pretty decent estimate of how much muscle you have, but not nearly as precise and specific as, again, some sort of MRI imaging could give you. Now, in order to appropriately calculate these values, the best way is if you can get yourself into a DEXA scan, or something like that, those are traditionally \$100 to \$200 or so, available in America, and plenty of other countries worldwide.

So a little bit less challenging and certainly more cost-friendly than the previous MRI stuff, but not free either. And so still may be outside of your cost range. If you want to take a step below that, most home scales come with the ability to use what's called BIA. And so this is effectively going to tell you your body fat percentage. You can use that in combination with your height, and get a rough estimate of your fat-free mass index.

Again, once you go down in scale, scientific accuracy, you start to lose some fidelity of measurement. But for a lot of people, that exchange of cost, difficulty, accessibility might be worth it, especially if you're just looking to see if you're close. If you're trying to see whether or not you broke a world record, we probably need to go a little more accurate method.

But for those of you that are just trying to get a basic understanding of am I significantly under muscled, am I OK? Where am I roughly at? Those are absolutely fine metrics to take and examine. Fat-free mass index, or FFMI is probably the most established metric to look at here. So I'm going to focus mostly on that one.

Interesting enough, there is no fundamental way to calculate this. There's a lot of nuance that can go into this that can alter your numbers in a decent amount of way. So it's important not to confuse you even more. But I do need to add that that is not as simple maybe as one would hope. Your hydration status on the day and other factors like that can alter it enough. So again, if you're looking for high precision, maybe pay attention to that.

But if you're just trying to get an estimate, this is still going to give you phenomenal numbers. There's also hundreds of papers published on this. And so you have a great scientific background to give you that context of where you're at. As an incredibly rough number, when we're looking at that FFMI, So? that fat-free mass index score, for men, I generally want to see them coming in at over 20. And for women, something like 16.5.

Again, this will scale up and down based on age. And you can look at a chart to see exactly where you're at. I'll give you some examples here in a second, but that's the collective number I want to look at.

Now, to give you a little of context of what some of the gold standards are here of total amount of muscle mass, we can have a little more fun. I want to take you all the way back to 1995. There's this classic study that came out. And it basically said, all right, the average gym goer is something like the neighborhood of 21.5 to 22 on an FFMI score.

And they actually theorized at that point that the only way to get past a score of 25 was to use exogenous hormones, again, specifically testosterone. Now, another reminder here. I'm not encouraging or promoting the use of hormones, especially outside of working directly with your doctor. But this is what they're establishing. What they're trying to identify is what is the genetic limitation of muscle

In other words, how much muscle can a normal human have outside of using exogenous hormones? And the answer they came up with was 24.8, or what's sort of roughly 25. That's been disputed since then, but that gave us a ballpark understanding. So when you're looking at your scores, if you realize that you're certainly in the 24, 25 area, this probably puts you close to what normal people are going to be outside of, again, exogenous hormone use.

But there's a lot of examples where people blow way past this. Of course, we never necessarily know if somebody had used things like testosterone in the past, but I'm going to make a pretty good argument for you right now that it's absolutely possible to go past that.

In fact, if you look at someone like Arnold Schwarzenegger in his heyday, kind of at his peak of performance, his FFMI score was about 28. Now, we obviously know Arnold has his history and past with exogenous hormone use. And so that still doesn't really change the case of saying, well, can we get past this 25 marker naturally? Well, let's look at some of the evidence here.

To give you a little bit of scoring context here. If you're at 23.5-- remember, 25 is the established limit, what we think to be natural. Arnold was at 28 with extensive steroid use. If you're at 23.5 for most men, this is going to put you in the 99th percentile. So already puts you in a phenomenal position.

However, there are data, initially, the first set of studies came out in sumo wrestlers. And now these are individuals that were well over 400 pounds, giving them something in the neighborhood of 260 to 270 pounds of lean body mass. Now again, that doesn't mean muscle mass. Lean body mass is including bone and water and things like that. But still, 260 or so pounds of lean body mass is a ton to move around in your system.

This gave them an FFMI score of about 35. Now, there's actually a famous case report that came out of one of the best power lifters of all time, Ray Williams. Now, of course, his name wasn't used in the paper, but effectively everyone knows who that was. And he scored a 41 on that metric, which just tells you how enormous and incredible athlete that Ray is.

Again, don't know about his steroid use in the past, doesn't matter. What I'm trying to show you right now is just what is the human potential for total amount of muscle mass we can put on a frame. Now, the magical number that tends to be thrown around here in terms of amount of lean body mass, what can have, is somewhere in the neighborhood of 110 to 120 kilos. Translation, 230 pounds or so, something like that.

The example I gave you earlier, of course, is a little bit higher than that, but that tends to be the kind of spot we can be. As you start manipulating body weight, hydration, status, what that does to muscle glycogen pulling water. The system, again, this can alter this number sort of day to day. So it's a little bit hard to interpret. But that's the kind of number we're going to put.

In terms of what this would put you in terms of absolute muscle mass, probably 60 kilos or so. And the reason is maybe we'll back up one quick second. Lean body mass of let's just say 120 kilos is the upper limit of what we think you have. Well, about 50%, 40%-- somewhere between 45% to 50% of that will actually be skeletal muscle.

And so if you have 120 kilos of lean body mass and half of that is muscle, this would give you the stratosphere of about 60 kilos or so of total amount of muscle mass. That's about the upper limit of what you'll ever see a human can have. Obviously, the numbers I'm giving you here are all in men. For women, that number gets significantly lower. But that just kind of gives you a ballpark of how much skeletal muscle one could have, how much lean muscle they would have, and then what their corresponding FFMI score would be.

There's two other things I want to point out before we move on. And the first is dealing with asymmetry. Now we're going to talk a lot about functional asymmetry, so when one muscle is stronger than another and vice versa. But the actual amount of muscle size matters as well. We don't have as much concrete data on this. And it also depends on your activity.

So for example, if you are an athlete of any kind, it may behoove you to have some amount of asymmetry. This allows you to create things like rotation and torque, to be able to throw a baseball 100 miles per hour, or to hit a golf ball 400 yards, or whatever the case may be.

But that said, there's clearly a point in which asymmetry within a muscle from side to side, front to back, et cetera is detrimental. Functionality is different in terms of quantity. Right now, some folks are going to say 5%, others might cut that line at about 10%. So if you were to get an

analysis and look at, say, how much muscle you had from a DEXA scan, and you were able to identify maybe your right leg versus your left leg or something like that, you would want to keep an eye on about that 10%.

Anything more than that is probably going to be a flag that there's some sort of issue or potential issue in the future. So total amount of muscle mass, FFMI is a great way to go about it. Asymmetry, pay attention to more than about 10%. And the second thing I wanted to point out here is what does it look like when I gain too much muscle? And I want to be clear here, and I believe that we've showed that in a recent paper we've published.

And that is excessive amounts of skeletal mass is not detrimental in any way. So there does not seem to be an upper limit where it actually starts compromising your physical health. Now, of course, if you've gained the muscle from non-exercise venues like what we saw in our NHANES database in our recent paper, then that's not great.

So an example here would be if you've just gained a bunch of body fat. And because of that, some muscle came along for the ride, that would be what we would consider to be muscle that I got accrued from non-exercise habits. This is not going to be advantageous to your health.

But if it is accrued from exercise, there doesn't seem to be any evidence at all that suggests this is negative, there are some papers out there that I think have made mistakes in identifying that after a certain point, an increase in muscle mass is actually negative.

And again, having analyzed some of those things myself in our recent paper, I think we found clear evidence that is not the case. There are other practical considerations. If you've exercised excessively, you've done it poorly or other things that have led to injury, of course, all those things are true. What I'm trying to argue is the simple fact of having additional muscle mass itself is not detrimental to health in any way.

Can be associated with other things that are bad for you that lead to injury and other metabolic problems. But the excessive amount of muscle mass on its surface is only going to aid in both your health and performance. We're going to make a number of these charts available to you in the show notes. But again, please acknowledge that they do vary a little bit from study to study.

So depending on which population was in a particular paper or how it was analyzed, the values might be a little bit different, but you're going to get you pretty close nonetheless. I want to give you a couple of numbers just to get you started, though.

Now these work on percentiles. What this means is when I say one percentile, that means the lowest amount of muscle mass, 99th percentile is the highest. Obviously, as we've been describing, you don't want to be low in muscle, whether you're an athlete or someone just

interested in overall wellness and health and longevity.

Higher is better. I actually personally prefer people to be in the 95th percentile or more, but I want to walk you through what this kind of looks like across the 25th, 50th, 70th, and then potentially up to 95th percentile. For men to be in the 25th percentile. Your FFM, my score would be about 17.9. In women, that would be 15.1.

Now notice how as you go from the 25th to 50th percentile, again, representing right in the statistical average or right in the middle. You've gone from, for men, 17.9 up to 19.1 or so. And for women you've gone from 15.1 up to 15.9 or almost 16. And so these numbers are not going to be huge in terms of what it looks like on paper, but that it does represent a large change in the total amount of muscle mass you have.

If you were to go from that 50th percentile to 75th, you've now gone up to 20.4 for men and 16.8 for women. As I said, I actually prefer people to be in the 95th percentile or higher because it provides no disadvantage whatsoever in overall health and performance. That's going to look like something like north of 22 for men and north of 18.1 for women.

Of course, if you're extremely ambitious and you want to challenge Ray Williams and his record of 41, by all means, be my guest, and please report back to me if you've accomplished such a feat. FFMI is not an intuitive number or score, so if I were to give you an FFMI score that puts you in the 75th percentile, you wouldn't really know what that means.

So let me explain to you how that number is calculated and run you through a couple of samples. And I'll do it both in the empirical, as well as in the metric units. Now, we know science works in kilos, so we will start there. Globally, when we think about body composition, we're thinking about how much muscle do I have versus how much fat.

But as I said, it's actually a little more complicated than that. So if you were to get something like a DEXA scan done or even stepped on a scale, and that gave you your body fat percentage, what it's telling you is, what percentage of your overall body weight is fat versus what is lean body mass. And remember, that lean mass is not just skeletal muscle, it is skeletal muscle plus bone and water and things like that.

So as a sample calculation, let's try this. Let's say you were 5 foot, 10", and weighed 100 kilos. Now I'm picking 100 kilos because it makes the math very easy. And for many of you listening, you're going to appreciate the fact that I've made the math somewhat simple for you. So if I were to be 100 kilos in weight, and my body fat percentage was 25, that means 25 of those kilos are fat and 75 are non-fat.

As I said earlier, most people that are decently trained anyways of their lean body mass,

somewhere between 45% to 50% of that is actual skeletal muscle. And so if we were to take that 75, divide that by 2, assuming 50%, this would mean you probably have something like 37.5 kilograms of actual muscle in your body. And again, 25 kilos of fat.

If you wanted to calculate your FFMI score from that, all you would have to do is go back to that lean body mass number, so in kilograms. So in this case, 75, and divide that by your height, so how tall you are, in meter squared. So if you're a 5 foot 10 inches tall, this is 70 inches, which would be about 1.778 meters.

So you take 1.778 square that, and then you take 75 and divide it by that number. This would produce, in this particular case, an FFMI score of 23.7. Pretty decent overall. You can also intuit if you looked at somebody who's 5 foot 10", they're 100 kilos and 25% body fat. This is an individual with a lot of muscle mass. And so this probably makes sense that they'd be on the upper end of that spectrum.

I'll run through that exact same thing now in pounds, for those of you that prefer that method. So 100 kilos would be 220 pounds. So just take the kilos, and multiply it by 2.2. If you were to run the exact same equation. So again, assuming 25% body fat, this would leave you with 165 pounds of lean body mass and 55 pounds of fat mass. Take that 165. Again, let's assume 50%, so we'll divide that by 2. And you would have 82.5 pounds of lean mass.

But nonetheless, we'll go back up. And you would take that 165-pound number. You would need then to convert that to kilograms, which means you divide it by 2.2, which would put you right back into that 75 kilogram number. Take that, divide that by the same units in meters squared of your height. And that would give you that same exact FFMI score.

So very easy to convert your body weight in pounds to kilos, convert your height in inches to centimeters, and then convert that to meters. Go online Google conversion. It'll do it in two seconds for you. And you're able to quickly calculate your FFMI.

Our third I of intervene, which is a fancy way of saying what interventions do I do? What stimuli do I introduce to aid in muscle growth? Now, I'm not really going to discuss muscle loss. I don't really see any advantage to doing that. So we'll focus on simply augmenting or increasing muscle mass.

A couple of things to get you started. While nutrition is an important consideration here, I need to make sure that it's completely clear here. Resistance exercise is by far the greater stimuli of muscle growth relative to nutrition. Really, from this perspective, we need to make sure we have sufficient calories, which is to be said as hypocaloric. So we need a little bit more calories than we're burning to just stay alive.

And mostly, we need to focus on protein here. 1.6 grams per kilogram of body weight is a great place to start. Now, I personally prefer a little bit higher 2.2 grams per kilogram, which is about 1 gram per pound. But actually, I believe the science is pretty clear here, suggesting that going from 1.6 to 2.2 is not really going to increase the amount of muscle you're growing.

And if it is, it's not going to be by much. And so if you prefer to be at 1.6, that's fine. Higher is absolutely OK as well. And it may aid in some people in some circumstances, but going below 1.6 seems to reduce the amount of muscle you can grow. So we want to be at least that number.

From a training perspective, you want to start by focusing on your big muscle groups. Now, if you have a particular muscle or group of muscles that you want to increase for any number of reasons, say you've identified an asymmetry, have a personal preference, you enjoy that more, you just want to have a muscle group grow larger for some aesthetic reasons, that's absolutely fine. Focus on those.

But you really shouldn't omit everything else either. It's critically important to maintain posture and joint integrity by ensuring we have adequate muscle surrounding each joint, which basically means we need to address each muscle at some point throughout the week. We can certainly emphasize some more than others. That's no problem whatsoever, but we don't want to leave big chunks of muscles completely unchallenged. That's going to present problems more likely, if not now, down the road.

So we also want to challenge these muscles across multiple stimuli, meaning exercises. So whether you prefer your body weight, machines, dumbbells, kettlebells or any number of other strategies, those are absolutely fine. All are incredibly effective. And at the highest level, it actually doesn't really matter that much which of those strategies you try, because at the end of the day, it's just about stimulating the muscle. However you go about that is absolutely fine. So you have lots of options there.

Perhaps in a future episode, we'll get into the details and spend the entire discussion on that, going over pros and cons of those different strategies and tactics. But for now, again, the most zoomed out level, you've got a tremendous amount of options regarding which exercise you select and which modes and methodologies you do to engage that resistance exercise.

The range of motion is critical. You want to use the largest range of motion you can, while still being safe and protective of both the exercising joint, as well as the joint above it and below it. So an example here. Let's just say you're interested in growing your quadriceps. You want to have a lot of activity over both the knee and hip joint. But you want to make sure that you're doing that in a case in which you're not compromising your low back and say your feet.

And so making sure we're protecting the joints above and below the muscle group is important as well. So we really want to challenge our muscles as much as we can in a variety of ways there. In terms of how much to do, the repetitions per set doesn't really matter in such that you can have success in a number of them. Anywhere between, say, as low as five repetitions per set, all the way up to 30 or more repetitions per set can be equally effective for muscle growth.

The total amount of sets per week is probably the bigger determinant. From there, you probably want to be in the neighborhood of about 15 to 20 working sets per muscle per week. If you were to break that down, let's say you were focusing, again, on your hamstrings muscles. If you did three sets on day one, three sets on day two, and three sets on day three, that would give you a total of nine working sets per week. That's probably a little bit too low.

But if you did two hamstring exercises each day, three sets each, that'd be six sets, day one, six sets, day two, six sets, day three. And now you're up to close to 18 working sets per month-- per week, rather. That's a pretty good spot to be in. Lots of things we could talk about there in terms of advanced athletes and elite, but structurally and roughly, that's going to put you in the ballpark. That's going to be enough stimulus for most people to grow most of the time.

Last consideration here is frequency. As I sort of alluded to here, somewhere between two to three days per week per muscle group is a great way to go about it. More is fine as well if you can handle the recovery. Less than two days a week is also theoretically possible. There's excellent research showing one day a week per muscle group is sufficient to grow muscle.

It does become practically challenging, though, because now you've got to fit all those working sets into a single day, and that is challenging both in the length of the workout as well as how sore and how much damage you create. So what I recommend here is what I call the 72-hour rule, which is every 72 hours or so, work each of your muscles to a nice pump or contraction.

Remember, we want to stimulate muscle growth here, but we don't want to annihilate the muscle either. Excessive fatigue and damage and soreness does not aid in muscle growth and can actually harm our ability to come back and train again in the next session, or even the one following that, which would then reduce our overall total volume.

So enough intensity, enough difficulty to stimulate growth, but not so much that we completely annihilate it. We got to be able to repeat that every 72 hours or so. So again, the way I say it, take it to a nice pump, a nice contraction, whatever that means to you. And that's going to get a lot of people in a close enough ballpark to growing muscle.

I'd like to take a quick break and thank our sponsors. Today's episode is brought to you by Maui Nui Venison. Maui Nui Venison is my absolute favorite thing to eat, period. It's beyond delicious

and the highest protein per calorie meat you will find. Maui Nui Venison is 100% wild harvested meat. Not fenced, farmed, or fed in any way.

The venison is ethically and sustainably hunted on the island of Maui, and is far beyond the quality of any beef, grass-fed, or whatever, you've ever tried in your life. And I know because I grew up in the country, and I've tried it all. It's easy to cook and taste incredible. My wife and small kids absolutely inhale it. And the jerky sticks are a daily staple for me with 10 grams of protein and just 55 calories. I literally ate two just now, and I sent it to school with my kids all the time.

While Maui Nui Venison offers the highest quality meat available, there is a catch. Supplies are limited by nature. Responsible population management means they won't go beyond the harvest capacity. Memberships are the best way to ensure that you can get the meat you want whenever you want it, so be sure to secure your spot now.

Maui Nui Venison is offering Perform listeners 20% off their first purchase of jerky sticks, fresh venison, and bone broth while supplies last. The bone broth, by the way, has 25 grams of protein in it itself. Visit mauinuivenison.com/perform for 20% off.

Today's episode is also brought to you by Renaissance Periodization. RP, as we call it in the industry, guides users through effective and easy to follow lifting programs all through their Hypertrophy app. These programs are designed by the absolute best in the industry, including one of my absolute favorite sports scientists and professional bodybuilder, Dr. Mike Israetel.

You may recognize that name because I've referenced him in his work countless times over the years. So whether you're looking to put on muscle gain strength, or both, these programs will help you achieve your goals and have produced results in literally thousands of men and women. Renaissance Periodization also has a diet app that is backed by the latest science and innovation in the fields of nutrition and takes the complexity out of dieting, helping you achieve your ideal body composition.

If you'd like to try Renaissance Periodization, go to rpstrength.com/perform to save up to \$50 off of your subscription. Again, that's rpstrength.com/perform to save up to \$50 off your subscription.

So now that you have a better understanding of how to identify, interpret, and then modify the amount of muscle you have, let's now talk about the quality of muscle. This is not as straightforward. I can't give you a simple equation or run you through a quick math problem. Because quality means different things to different people in different scenarios. So rather than try to give you an exhaustive list of all of them, I'll start with just a couple of examples and let you

infer on past that.

The first thing to consider here is really not specific contractile properties of an individual muscle, but collectively how you move. Now, I'm not going to get into this fully, but really quickly, it's important to understand how an individual moves the quality of that which muscles are using, for which muscle group, their technique, how that is portrayed across the joint is important for all of us.

Again, whether we're in a sporting context or just general life. And so when I'm thinking about, yeah, how much muscle do I have, and then also what's the quality of that muscle, I need to be thinking about how that muscle is actually used. As a simple explanation HERE I look for basic things when determining successfulness of human movement.

If you're in a specific sporting context, you're, of course, going to add your own unique flavor. So how a Major League Baseball pitcher moves is going to be quite different than even somebody like a golfer, who are both in rotational, asymmetrical sports, how they move, you can expand that even beyond that to somebody like an NBA player or a pickle baller.

All of these coaches and athletes in the individual sports are going to want to have different muscles move in different fashions, in different sequences. I can't get into all those details now. So just stepping back and thinking globally, what are the core principles that are true in all those examples, to me, it's really four basic elements.

The very first one is range of motion. Are you able to go through a range of motion in all of your joints that is appropriate for those joints? As an example, your elbow is meant to flex and extend. It can rotate internally and externally. This would imagine taking your palm of your hand and sticking it up in the air, and then taking the palm of your hand and sticking it towards the ground. Internal and external rotation.

However, your elbow is not meant to bend left and right. If you want to move your hand in closer to your body or away from your body, you actually have movement of your shoulder joint. And so an elbow has a few ranges of motion. A shoulder, though, can go up and down and front and back. It can rotate and kind of roll itself internally.

And so each joint has a different range of motion it can go through. So can you go through all those range of motions in a way that's appropriate without being too much range of motion?

The second thing we want to pay attention to here is rough symmetry, like we've talked about a couple of times already. So symmetry means again, am I OK moving front and back within one joint or groups of muscles? And then how does that compare to the contralateral or opposite side?

So if I can lift my, say, right shoulder straight out in front of me, and I can lift it all the way over my head so that it's pointing directly in the sky, but my left shoulder can only go 80% of the way, then I have some sort of asymmetry. Is it the front and back? So my shoulder on the front side of it is twice the size of the back side of it, things like that.

So we want to look at do I have global asymmetry, especially when we're doing what is called bilateral movements. So imagine doing like a squat. Picture a basic air squat or a goblet squat, where you're holding an implement in front of you, or you're squatting down like you would do to hold a child or a baby or something like that.

In doing that, I would want to be looking at all of my joints. And I would do this one by one. So starting at the ankle joint, I would say, OK, great. Can my ankles go through a full range of motion, or are they restricted and then therefore causing a movement compensation at the knee or hip or some other joint?

Are they symmetrical? Is one facing a different direction than the other one? Does one have more range of motion than the other one, et cetera, et cetera. So that's just one example of how we would look at the range of motion and symmetry within one joint.

The third thing we want to look at is stability. Let's imagine that same squatting movement. So I want to look at now, say, my knee. I'm going to ask the same thing. Can my knee go through a full range of motion? Is it symmetrical? So is the left knee doing the same thing that the right knee is doing. And then thirdly, now, is it stable? So is the joint able to go up and down under control without excessive wobbling or shaking or any other movement pattern that I'm not intending to do?

To me, that's stability. Really, you're talking now a combination of motor control and strength, but we can globally think of that as, is the joint stable when I'm asking it to be stable? Human movement is really two things. It is asking a joint or muscle or muscle groups to move in a way that we want, and also at the same time not move in ways that we don't want. Both of those are critical to moving well.

The third and final element here is simple awareness. So is the individual aware of what their joint is doing? A lot of times movement dysfunction like this is simply somebody not knowing their foot is not supposed to point in that direction. Somebody not realizing that one side is aimed at another direction than the other side. So simply letting people know that their joint is not supposed to be doing that. That's not a proper pattern. It is a critical component.

So from the onset, and again, we can maybe have further discussions about this in future episodes, moving well needs to have those four components at each joint throughout our body. If

we can do that, we can set aside the injury risk and stuff and again, talk about that later. And we can move on to really performance.

Now, when I'm asking about a muscle or muscle groups to perform, I care about three things. Can it be fast? Can it be strong? And can it have what's called muscular endurance? This can be expressed over a concentric muscle action, an eccentric or an isometric. So generally, when we say concentric, we're thinking about shortening of the muscle length.

So imagine doing a biceps curl. When you're actually taking the dumbbell and moving it closer towards your shoulder or your face, that muscle or muscle group is shortening. That would be the concentric portion. If you got all the way to the top or say, halfway up, or any part of the range of motion, and you stop the movement and held it there, that would be isometric.

And then if you lengthened it back down all the way to the bottom, that would be the eccentric portion of it. And so I want you to have the ability to be fast in any of those ranges of motion or any of those muscle actions. I want it to be able to be strong in any of those muscle actions. And then I want it to have the ability to repeat that multiple times.

This could mean repeating holding the position. So if I could go to say halfway up, I could flex and hold it there. I want to be able to hold it for as long as I need, based on the specific muscle or the movement I'm trying to do, or be able to perform multiple repetitions. If we're looking at basically any style of human movement, it's going to need to be fast. It's going to have to be strong. And it has to display some semblance of muscular endurance.

So if I summarize all of this, the way to investigate whether or not you have sufficient muscle quality has two unique parts. Part one is understanding. Do you move well? Now that definition of move well really changes depending on the sport or the context. The way that your hamstrings need to contract for 100-meter sprinter are quite different than somebody who wants to just be able to hike all day, or a cross country skier or anything else.

So it is context specific, but I gave you an example of four things that are generally pretty universal regardless. Your muscles need to go through an appropriate range of motion. They need to be symmetrical. They need to be stable, and you need to be aware of what they're doing. If you're aware of the context, say you have a specific sporting outcome, then you can lean on a coach or an individual in that area.

If not, there are plenty of global movement screening tools. So these are different tests you can do that will allow you to understand a basic human movement pattern. Many of them to choose from. We could probably put some in the show links for you. There are some nuances within plenty of them, but something like that should be chosen.

You have a lot of options. I would strongly recommend, though, picking at least one thing from the how do I move column in order to investigate. Is your muscle functioning appropriately? The second thing then is some sort of performance metric. So this could be something simple, like a leg press machine, or more complex, like a single-leg squat, or anywhere in between.

And within that, you want to identify whether or not the muscle is capable of moving fast, moving strong, and can repeat that performance over multiple repetitions. Helping you interpret your score on a movement screen is really challenging without having a lot more individual context. So what I'd like to do is give you some more straightforward and specific examples from the metrics of speed, power, and strength.

In sticking with the theme of this show, I wanted to give you some context as to what the best in the history of the world look like for muscle speed, power and strength. In my opinion, no one typifies muscle speed more so than 100-meter sprinters. This is the quintessential best test in the world of maximum velocity.

And so when we look at the best two names, jump off the chart, of course, from the female perspective, this is Flo-Jo, the American sprinter. And then from the male perspective, no one comes close to Usain Bolt. So how fast were these two individuals? Well, a little bit of context here. It took about 40 years and 11 individual men to drop the world record in the 100-meter dash by about 2/10 of a second, from 9.95 to 9.74.

Bolt did nearly the same thing all by himself. He dropped the world record by 0.16 seconds, all the way down to 9.58 seconds over the course of his career. So he, himself, represented almost the same progress as the entire field made in 40 years. That's how much faster he was than anybody else ever before him. And still, to this day, no one has come even close to matching that feat.

In fact, only two people ever have run 100-meter dash in under 9.7 seconds, which means Usain Bolt is over a tenth of a second faster than anyone ever in the history of the competition. Now, there's actually a lot of interesting people who try to understand and examine why he's so much faster than anyone else.

There was an interesting paper that was entirely speculative, was not from his team, but some biomechanics researchers tried to figure out what would be possible for him to do that. And the best that they could estimate was that his fast twitch fibers, which we talked about earlier in the show, are about 17% faster than other world class caliber sprinters.

Again, this is entirely speculation. We don't know if that's true. There's no data or evidence of biopsies. That's public record of Usain Bolt, although I've been on record for many, many times,

saying, I would love to take that biopsy, if you're listening, Usain. But of course, some of the magic that goes into sports performance is we don't always get to know why people are, how they are.

Now, something else I find extremely interesting about this is what happens to maximum speed as we age. And the reason I'm drawing this out is we talked earlier about how preserving these fast twitch muscle fibers is critically important. And if you look across World Records as we age in speed activities versus strength versus endurance, a clear pattern emerges.

People drop maximum speed capability way faster as they age than they drew strength. And then certainly endurance. In fact, the world records in most endurance-based activities really don't change from folks who are 35 years old to 40 or so. And when they start dropping at 45 to 50 plus, it is fairly small until we get to advanced stage.

Speed, on the other hand, falls off a cliff almost immediately. As an example, I told you, Usain Bolt's record is just a second ago 9.58 seconds. If you go to the first age category, which is 35 years old, the world record jumps up to 9.87 seconds. And that's just at 35 years old.

If you're in an endurance sport, that actually might be in your actual prime still. It gets even further faster. As we go to 40 years old, that record jumps to 9.93. And then at 45, it is a whopping 10.7 seconds. So you're talking about now addition of well over a second by just going to the age of 45.

To this date, I'm not aware of any human ever running a 100-meter dash in under tens over the age of 40 years old. So extraordinarily challenging. As we go on, just to rattle off a few additional numbers, every five years or so you add on to age, you're going to look at an additional half a second or so increase in your 40-yard dash time.

For those of you that are curious, the world record for a 100-year-old male is 26.99 seconds. In fact, the highest number I've seen was just a few years ago, a 105-year-old ran a 34.5 second 100-meter dash. So I'm not sure where you're at. You're welcome to go out and time yourself on this. Please don't tear your hamstring. Maybe warm up and try it a few times before you go full maximum speed.

But I hope most of you can come in under that 34.5 seconds. If not, rest assured there's 105-year-old out there somewhere who will beat you in 100-meter sprint, and that's embarrassing.

Coming back to the female side, Florence Griffith Joyner, or Flo-Jo, as I referred to her earlier, still holds the world record at a time of 10.49 seconds. And to give you a little bit of context of how dominant that was, it is still the record some decades later. And I believe there's only one

other female to ever run below a 10.6.

So tremendous speed on her part. We could play the same game here as age goes on, although it is a little bit less dramatic than the men. The world record for 35-year-old is held by a still current and competing star, Shelly-Ann Fraser-Pryce at 10.62 seconds.

As you go up to the 40-year-olds, you're talking about now, again, a similar half a second or so jump to 11.09 seconds. And then it continues really on from there. All the way to the end there, you've got a 100-year-old coming in at a smoking 39.62 seconds, and then of course, a 105-year-old, a little bit slower at a time of 1 minute and 2.95 seconds.

So as I mentioned, if you're a woman out there and you can't run a 100-yard dash in under a minute, again, there's 105-year-old out there who will smoke you. Running 100-meter as fast as you can may not be the best test for many of you out there. And so while I think that speed is critically important, and it is different than power, many of you could probably get away with just a simple test of power. And you have a lot of options that are more realistic and probably a little safer for many of you.

If you're an athlete or competitor of some type, a lot of ways you can go about this. Of course, you can use things like a force plate, which is an incredibly expensive and fancy scale that can tell you exactly how much force and how much time it takes you to push into the ground.

Other options are just simply doing something like a vertical jump test or a broad jump test. A very, very easy rule of thumb that I like for the broad jump. And this is, again, a horizontal jump. So how far out in front of yourself can you jump is can you jump your height. So if you're 6 feet tall, can you jump 6 feet?

High level athletes are going to be looking more like 9 to 10 or even 11 feet in that jump. But a basic metric for the average person is can you jump your height? Vertical jump is actually my favorite way. You can do this easily with just a tape measure. Put a mark on the wall, tape how high you can jump. Measure it that way.

As far as I know, and actually, I checked around with a bunch of colleagues on this, there's no scientifically verified world record for this. Guinness has their own records. The scientific publications are a little bit different. And so I actually called a friend of mine, Paul Fabritz. Paul is a world renowned basketball trainer, has coached and worked with some of the best basketball players in the world.

And I asked him, and he told me basically, in his opinion, 48 inches or so is the highest he's ever seen. And this would be a standing vertical jump. If you were to get an approach, say maybe two or three steps to run in, you might be able to jump into the low 50s. But he doesn't really think

anybody has eclipsed the 50 inch mark in terms of a standing vertical jump.

There's not extensive evidence on vertical jump height by age. And so that's a little bit more challenging to give you. So what I would say is, again, focus on something more like that broad jump test. Another option is to use machines like a Proteus. Now, you may have this available depending on where you train at your local gym or clinic somewhere.

And these are machines that allow you to test your power in a number of different planes. And this is really interesting because companies like this are starting to collect normative data on average people for power testing. And I don't have anything like that to report to you right now.

And so what's going to be hopefully interesting in the coming years is as they start to release and publish these results, I will have normative values based on age and sex for things that are not just vertical jump-based. Not all of you can do that. You may have, say, ankle, knee or back injuries that don't allow that or it's not realistic or for some other reason.

And so being able to identify and test your power in things like rotation and vertical movements that don't require jumping and landing are things that I hopefully am able to share with you in the coming years once those data become available.

Now, technically, the highest power outputs seen in the literature come from weightlifting or what's more effectively known as Olympic weightlifting. So both the athletes themselves, as well as the movements. So the snatch, clean, and the jerk and variations of this produce extraordinary amounts of power. The problem is, if you're not extremely technically proficient in these activities, you can't really test your power with them because you'll be limited so much by your technique, we won't get a true expression of your power.

So if you're familiar with those movements, they are a fantastic way to globally test your power. If not, you might want to opt for something more like that vertical or broad jump test. So to round us out here, let's talk about strength. There's a lot of different things I could pull up here, but the most direct, plain measure of absolute strength comes from the sport of powerlifting.

Now, not to be confused with Olympic lifting. This is the sport of a one repetition maximum in the deadlift, bench press, and back squat. There's a lot of different federations and rules and all that. And so to not bogged down in unnecessary information, I'm going to give you the numbers that represent what's called the equipped category, which is to say the highest amount of equipment possible, what's just the most amount somebody ever lifted.

There are subcategories like raw, which says you can't have certain equipment like belts and wraps and straps and special shirts and things like that. You could debate whether or not you find one more relevant or interesting than the other one. I don't really care. I just want to share

with you the most amount ever lifted in a human without some arbitrary rule that these organizations have set.

Now in powerlifting, you get to find your one repetition maximum among those three exercises, and you can also combine them together to get a total. So from the men's perspective, there have only been two ever to cross the 3,000 pounds barrier, such that between the three exercises, squat, deadlift, and bench, they totaled more than 3,000. pounds

The two gentlemen, Donnie Thompson and Dave Hoff, Hoff having the current world record at 3,103 pounds. Now my longtime friend AJ Roberts, actually, might have a better resume here. He totaled 2,855, pounds but did it at probably 30 or 50 or so pounds lower than these other two gentlemen. I'll let them all figure that out. But nonetheless, almost 3,000 pounds across three different exercises.

If you want to go through the exercises individually, we have different people with world records there. So the squat right now, current world record is from Nathan Baptist, at an astounding 1,311 pounds. Again, friends, you heard that right. This is 1,300 pounds back squat.

From the bench press, this was actually just recently broken. Jimmy Kolb did this. And this is unbelievable. The world record is now 1,350 pounds. The previous world record, he broke by almost 200 pounds. I don't know if this is more impressive than the Usain Bolt, but hard to argue when you beat a world record by an additional 200 pounds. That's simply unbelievable, that strength accomplishment.

Another actually fun thing to note here is, I believe, fifth or sixth on that list, is a gentleman named Bill Gillespie, at a total of 1,129 pounds. He actually also did this pretty recently. And the fun part about Bill is two things. One, he's 62 years old. You heard that right. 62 years old. And just I think last year, bench pressed well over 1,100 pounds.

The other thing interesting about Bill is he was actually one of my first mentors. When I was an undergraduate student, Bill was the head strength and conditioning coach at the University of Washington. I'm from that area. And so I was fortunate enough to beg bill to let me come up and shadow him one day. And he said, fine, you can do that, but I'm training.

And so I showed up there probably 30 minutes late. I was beyond embarrassed. Thought, don't even go in, go home. This is so ridiculous that you showed up this late for a guy like that. He was the kindest, sweetest guy ever put in his mouthpiece, had his training logs out there, and proceeded to do one of the most impressive training sessions I've ever seen, while giving me guidance of being a strength and conditioning coach.

I'll also never forget Bill looked at me, now in context, you can imagine what Bill looks like at the

time. Myself, I'm a 5 foot 8", probably 180 pounds at the time, college football player, but still incredibly small compared to him. And I will never forget the words he said to me. It made a huge impact on my life.

I asked him about being a collegiate strength and conditioning coach, as I thought this was what I wanted to do with my life. And he looked at me straightly and directly and said, you're a dime a dozen, you don't matter. And he didn't say it with hate or hurt at all. It was the kindest, most direct and helpful thing I've ever heard. It changed the trajectory of my life. And it made me realize if I wanted to make it as a strength and conditioning coach, I was going to have to do a lot more than to just show up with my exercise science degree.

The third and final exercise, the deadlift, was set by the famous Andy Bolton, who I believe is the only person, still to this day, to ever deadlift more than 1,000 pounds at 1,008.

Now, from the female side of the equation, you have some equally impressive, if not, more impressive numbers. The world record total, there has only been two women ever to cross the 2,000 pounds barrier. That would be Becca Swanson and Leah Reichman. Swanson currently owns that record at 2,050 pounds.

The individual records, the squat, Leah holds that record at 925 pounds. I don't know when she's going to cross 1,000, but I keep watching to see when it's going to happen. That would be just absolutely insane to see. And good luck to you, Leah, on that one.

The bench press, Rae-Ann Miller currently holds that record at 650 pounds. And then the deadlift is currently set by Becca Swanson at 694 pounds. So now that you know what that gold standard really is for strength, what are some more realistic numbers for the average person?

For men, I'd like to see about a one to one ratio for the bench press, such that you should be able to bench press your body weight. So a 200-pound person should be aiming for something like 200-pound bench press. For women, it's about 0.6. Upper body strength is significantly less in women in general. And so you're going to have to scale that down a little bit more.

Now, for the back squat, it's hard to give you numbers because it is so technically demanding. I think it's easier to give you something more like a leg press value. For men, you want to shoot for something like double body weight. And for women, something like one and a half times or so. So that hopefully gives you a little bit of context of the numbers to go after.

Last thing I want to add here is actually something we'll talk about a lot more in the future. And that is grip strength. It is incredibly important, and a great insight into your overall health, for both athletes and non-athletes. Easy to test. There's a number of ways that you can grab hand grip dynamometers. They are cheap and available almost anywhere.

For men, just again a rough number here. I like to see individuals over 45 kilograms. And then for women, over 28 kilograms or so. Another thing to keep in mind here is asymmetry really matters. Now this is the first test I've given you where you can isolate your left side from your right side.

Really important to test your grip strength in both. Recent papers have come out, suggesting that asymmetry of more than 10%, specifically, increases your risks of sarcopenia and heightened denervation of muscle groups by 2.67 fold. And so we will talk about that more in detail later. But really, really important. You want to understand whether or not you have major asymmetries in strength between both your sides.

Again, some asymmetry is probably OK, maybe even advantageous for some sporting applications, but asymmetries outside of that are potentially concerning. If you're unfamiliar with that term, sarcopenia describes the excessive loss of muscle mass with age. We know there's going to be some sort of natural decline in the amount of muscle mass you have.

In fact, on rough average, men will lose about 40% of their muscle mass from the ages of 25 to 80. So we know it's going to happen. We've talked about how strength training and adequate nutrition can reduce that loss of muscle, but some of it's going to happen. So sarcopenia really refers to the excessive or additional loss of muscle beyond the normal loss with aging.

So those strength standards I gave you are rough guidelines. But I want you to get as strong as possible. I don't necessarily need you to be squatting or benching 1,300 pounds. But I don't want you to just stop at bodyweight either. So outside of, of course, leading to injury and getting hurt, which is something we don't want to do, there's no disadvantage to getting stronger.

I tried to make that argument with muscle mass earlier in the show, but I can really make that heavily with strength. In fact, if you were to compare the two, muscle mass, the muscle strength, muscle strength is by far a stronger predictor of both how long you're going to live, as well as how well you will live within those years. That's number one.

Number two, getting stronger only continues to reduce your risk of developing things like sarcopenia or late onset dementia. In fact, one particular study of note here, this study had around \$500,000 or so individuals pulled from the UK Biobank, which is a similar setup as what we've got here in America that I talked about earlier in our NHANES database.

Now, they studied these individuals across nine years. And during that time, around 4,000 or so individuals developed dementia. And so what's interesting is they're able to go back and say, OK, what unique characteristics existed prior to the dementia, as well as after the onset? And how did that compare to the individuals who didn't have the dementia set in?

And in this one certain study, and just one study, so we want to be cautious of overinterpreting here, what they found was 30% of dementia cases were attributed to having low grip strength. And this was independent of a number of other important confounders. We will talk about these things more in future episodes.

And I don't want you to get overly concerned with that specific result or those specific numbers. I just wanted to highlight, though, the critical importance of getting stronger really helps overall global health. And what's furthermore interesting about this paper and many, many, many others is there doesn't seem to be an upper limit.

So when you continue to increase strength, you continue to reduce risk of all cause mortality, dementia, and similar other things. And so we don't see this really even in asymptote. We don't see a tapering off of benefit. We just continue to see rises in improvements in risk reduction factors, hazard risk, mortality risk, a number of other things important to overall health when we continue to get stronger, whether we're talking about grip strength, leg strength, or anything else.

And so it just, right now, according to the data across, again, multiple areas, just continuing to get stronger seems to continually benefit human health and performance.

At this point, we can now move into our final I, which is intervene. In other words, what do you do to improve your muscle quality? I'm going to give you four big areas to focus on. The very first one is similar to what we talked about for muscle quantity. And that is you want to train all of your joints through all their ranges of motion.

One thing people fail to realize is it's good to be strong, but you need to be strong and fast and have good endurance over the entire range of motion. You're going to be put into positions likely, where the muscle needs to contract, when it's shortened, when it's extended, and many other positions. And so we want to train that, somehow, across multiple range of motion.

The first is similar to what we talked about with muscle quantity. And that is all ranges of motion. You want to be strong, fast, and have great endurance when your muscles are both shortened, when they're extended, and when they're in various positions. As always, we don't ever want to put a joint into a bad position, and then we definitely don't want to load that or contract that.

But as much as we can, we want to force human movement and a high quality through a large range of motion. The second one here is being intentional. So where this differs than, say, the muscle size issue is muscle quality is about eliciting an improvement in human movement, whether this means we're more efficient, whether we're producing more power or speed, we've got to move in a certain way.

And so now we're talking about a quality that extends outside of the muscle itself and into a

human movement. And so we want to be incredibly intentional about how we're moving, our technique, our rhythm, our timing, our tempo. What should be moving, what should be relaxed, what should be contracting is all critically important to moving better.

If you ask any sprinting coach, they're going to talk about things like rhythm and timing and tempo. And what they're really talking about is this stuff, how this applies to everyone else is simply understanding when I'm trying to contract, say, my pecs or my shoulders for a bench press, what should my glutes be doing? Should they be contracted all the way? Should they be totally off and relaxed? Should they be halfway? Things like that.

So paying attention to your movement quality is the fastest way for most people to actually move faster and move stronger. Improve technique first, and then chase after improving maximal capacity of the actual muscle fiber and tissue.

The third is in making sure you're balancing movement planes and posture. So if you want to get a better squat, make sure that your glutes aren't significantly stronger than your hamstrings, or your adductors, your groin and the muscles that kind of pull your knees together aren't significantly weaker. You will only ever be as strong and as fast as your weakest link in that movement chain.

So ensuring you don't have anything grossly behind something else, and that you're training yourself so that the muscles move appropriately. Think about it this way. There are some muscles and joints that are meant to be stable and others that are meant to be movers. And they tend to stack in on every other one fashion such as this. I gave the examples of the knee and the hip earlier.

The ankle is meant to be highly mobile and to move a lot. The knee is meant to be stable. So if the knee is stable, this allows the ankle to move a lot, and then the opposite direction would be the hip. So you want a highly mobile hip, a highly stable knee so you can have a highly mobile foot.

Going above that, since the hips are mobile, you want the low back and the lumbar spine to be stable so that the thoracic and kind of mid back spine can be mobile so that your shoulder joints and your neck can be stable. This allows then the shoulders to be mobile, the elbows to be stable, and the wrist to be nice and mobile.

Now it is more complicated than that, but really, at the highest level, that is a nice summary of how the muscle actions are supposed to work. If you think about that in general context, it's going to keep you pretty safe and it's going to allow you to move well.

Lastly, then, is what I call the three to five rule. So the three to five rule applies to strength,

power, and speed. What it roughly means is this choose three to five exercises. Do three to five repetitions for three to five sets. Rest for three to five minutes in between each set, and repeat that three to five times per week.

So at the lowest level, this could mean three sets of three repetitions, three days a week of three exercises. This would be a pretty low volume, but because of that, that would allow you to go really, really heavy or at a really high intensity. You're going to have a lot of recovery. You're not going to stimulate a lot of muscle growth, won't stimulate hardly any muscular endurance, but could be used if you're trying to maximize the recovery ability or the strength aspect.

Going higher on that spectrum, say, five sets of five of five exercises five days a week would get closer to the hypertrophy or muscle growth under the spectrum, would give you a little bit more muscular endurance, and would be a lot more volume for those individuals who are a higher training status.

For muscular endurance, you can add any number of things, more repetitions per set. More sets, less recovery between sets, or anything else like that. Training to a little bit of fatigue is a pretty easy way to think about muscular endurance. Of course, exercise science is an entire scientific field. It gets far more complicated than that, but that is a rough idea of how to intervene, to change the quality of contraction of which your muscles can go through.

So to wrap everything up, today we talked a lot about skeletal muscle. We went over how it actually works, what it's made of. Why, in my opinion, it is the most important organ in the entire body and deserves more credit and attention. We talked about why you want to make sure that it is functioning at the highest level possible.

This means both a quality of muscle, functionality, contractile properties, how much force it can produce, how fast it is, and other things like that, as well as the quantity of it, how much muscle you have in general. We went into a little bit of the microanatomy. So the difference between fast twitch fibers and slow twitch fibers, and why it's important that you pay particular attention to high force activities in order to preserve those fast twitch fibers, regardless of whether or not you're an athlete or a person interested just in longevity and overall wellness.

So from there, we talked about the three I's, the first being investigate. So identifying whether or not you have enough muscle and how it's functioning in terms of power and speed and so on. The next I, of course, was interpretation. So letting you know whether the amount of muscle and the strength and power you have is good, great, close to some of our world records, whether you're male or female, or maybe not quite as high as you think.

And then lastly, to intervene. So what do you do about it? What are some protocols and things

you need to do from a lifestyle perspective to improve the both muscle quality and quantity?

I hope you found this initial discussion of skeletal muscle interesting and useful. Now when I say initial, it's for a reason. I have a lot more to tell you about skeletal muscle, but we're going to have to save that for future episodes.

Thank you for joining for today's episode. Our goal is to share exciting scientific insight that helps you perform at your absolute best. If the show resonates with you, and you want to help ensure this information remains free and accessible to anyone in the world, there are a few ways that you can support.

First, you can subscribe to the show on YouTube, Spotify, and Apple. And on Apple and Spotify, you can leave up to a five-star review. Given that we're a new podcast, subscribing and leaving a review really does help us a lot. Second, please check out our sponsors. The show would not exist without them, and they really are exceptional products and services.

And then finally, you can share today's episode with a friend who you think would enjoy it. If you have any content, questions, or suggestions, please put those in the comments section on YouTube. I really do try to read these and see what you have to say.

I use me on Instagram and Twitter also exclusively for scientific communication. So those are great places to follow along for more learning. My handle is DrAndyGalpin on both platforms. Thank you for listening. And never forget, in the famous words of Bill Bowerman, if you have a body, you're an athlete.