Welcome to the Huberman Lab podcast where we discuss science and science-based tools for everyday life. I'm Andrew Huberman and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today my guest is Dr. Andy Galpin. Dr. Galpin is a full and tenured professor in the Department of Kinesiology at California State University in Fullerton. He is also a world expert in all things exercise science and kinesiology. Today you are going to hear what is essentially a masterclass in how to build fitness no matter what level of fitness you happen to have. He talks about how to build endurance and the multiple types of endurance. He talks about how to build strength and hypertrophy which is the growth of muscle fibers. So if you're seeking to get stronger or build bigger muscles or build endurance or all of those things, today you're going to learn how. You're also going to learn how to build flexibility, how to hydrate properly for exercise, and we'll also talk about nutrition and supplementation. What makes Dr. Galpin so unique is his ability to span all levels of exercise science. He has the ability to clearly communicate the sets and repetition schemes that one would want to follow, for instance, to build more strength or to build larger muscles. He also clearly describes exactly how to train if you want to build more endurance or enhance cardiovascular function. What's highly unique about Dr. Galpin and the information he teaches and the way he communicates that information is that he can take specific recommendations of how recreational exercises or even professional athletes ought to train for their specific goals and the link that to specific mechanisms, that is the specific changes that need to occur in the nervous system and in muscle fibers and indeed right down to the genetics of individual cells in your brain and body in order for those exercise adaptations to occur. It's truly rare to find somebody that can span so many different levels of analyses and who is able to communicate all those levels of understanding in such a clear and actionable way. Indeed, Dr. Galpin is one of just a handful of people to which I and many others look when they want to make sure that the information that they're getting about exercise is gleaned from quality peer reviewed studies, hands-on experience with a wide variety of research subjects, meaning everyday people all the way up to professional athletes in a wide variety of sports. So it's no surprise that he's not only one of the most knowledgeable but also the most trusted voices in exercise science. Dr. Galpin is also an avid communicator of zero cost to consumer information about exercise science. You can find him on Instagram at Dr. Andy Galpin and also on Twitter at Dr. Andy Galpin. Both places he provides terrific information about recent studies both from his laboratory and from other laboratories, more in-depth protocols of the sort that you'll hear about today. So if you're not already following him, be sure to do so. He provides only the best information. He's extremely nuanced and precise and clear in delivering that information. I'm certain that by the end of today's conversation, you'll come away with a tremendous amount of new knowledge that you can devote to your exercise pursuits. I'm pleased to announce that I'm hosting two live events this May. The first live event will be hosted in Seattle, Washington on May 17th. The second live event will be hosted in Portland, Oregon on May 18th. Both are part of a lecture series entitled The Brain Body Contract, during which I will discuss science and science-based tools for mental health, physical health and performance. I should point out that while some of the material I'll cover will overlap with information covered here on the Hubert-Mind Lab podcast and on various social media posts, most of the information I will cover is going to be distinct from information covered on the podcast or elsewhere. So once again, at Seattle on May 17th, Portland on May 18th, you can access tickets by going to Hubert-Mind Lab.com slash tour, and I hope to see you there. Before we begin, I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is, however, part of my desire and effort to bring zero cost to consumer information about science and science-related tools to the general public. And now for my discussion with Dr. Andy Galpin. Welcome Dr. Professor Andy Galpin. It's been a long time coming. We have friends in common, but this is actually the first time we've sat down face to face. Yeah, I'm very excited. Yeah, there are only a handful, meaning about three or four people who I trust enough in the exercise physiology space. That when they speak, I not only listen, but I modify my protocols and you are among those three or four people. So first of all, a debt of gratitude. Thank you. You've greatly shaped the protocols that I use. And I know there's far more for me and for others to learn. So your professor, you teach in university, and you have a tremendous range of levels of exploration, muscle biopsy, literally images down the microscope all the way to training professional athletes and everything in between. So you are truly an end of one. And just to start us off, I would love to have you share with us what you think most everybody or even everybody should know about principles of strength training. And principles of endurance training and principles of let's call it hypertrophy power and the other sort of categories of training. And this could be very top contour. But what do you think everybody on planet earth should know about these categories of personal and athletic development? Well, that's a great first question. Holy cow, I think I'll start it this way. I tend to think about there's about nine different adaptations you can get from exercise fat loss is not one of those it is a byproduct but that's not really what I'm getting at. And so we can kind of categorize everything like that. And what we're going to we can talk about are what are the concepts that you need to hit within each one. And then you could have infinite discussion of the different methodologies. Right. And so that that first thing to hit is the concepts are actually fairly few. But the methods are many right people have said that in iterations throughout time. So if you walk from the very beginning the first one to think about is what we'll just call skill. So this is improving anything from say a golf swing to a squatting technique to running. And this is simply moving mechanically how you want your body to move. I'm just going to globally call that skill from there we're going to get into speed. So this is moving as fast as possible. The next one is power and power is a function of speed but it also function of the next one which is strength. So if you actually multiply strength by speed you get power. And the reason I'm making this distinction by the way is some of these are very close and I'm going in a specific order on purpose here. For example, power is like I just said it's a function of speed and strength. So if you improve speed. You've also likely improved power but not necessarily because it could have come from the forest direction either. So there's carry over so like the lot of things that you would do for development of strength and power. They are somewhat similar but there's differences right so things that you would do correctly for power would really not develop much strength and vice versa. So we can get into all these details later. Once you get past strength and the next one kind of down the list is hypertrophy. This is muscle size right growing muscle masses one way to think about it. After hypertrophy you get into these categories of the next one is these are all globally endurance based issues and the very first one is called muscular endurance. So this is your ability to do how many pushups can you do in one minute. You know things like that past muscular endurance. You're now into more of an energetic or even cardiovascular. If it takes you left the local muscle and you're now into the entire physiological system. And it's ability to produce and sustain work and we can get it to a bunch of different variations with an endurance but just to keep it really simple right now. The very first one think about this as I call this anaerobic power right so this is your ability to produce a lot of work for say 30 seconds to maybe one minute. Kind of two minutes like that the next one down then is more closely lined what we call your VO to max. So this is your ability to kind of do the same thing but more of a time domain of say three to 12 minutes. So this is going to be a maximum heart rate but it's going to be well past just max heart rate. After that we have what I call long duration endurance so this is your ability to sustain work. The time domain doesn't matter in terms of how fast you're going it's how long can you sustain work this is 30 plus minutes of no break like that so as just a high level overview. Those are the different things you can target. And again some of those crossover and some are actually a little bit contrary to the other one so pushing towards one is maybe going to sacrifice something else so as an overall start that's really what we're looking at within all those though they do have similar concepts in terms of there is a handful of things you have got to do to make all of those things work and we can talk about as many of those as you want one of them is functionally called progressive overload. So whichever one you're trying to improve at if you want to continue to improve you have to have some method of overload and as you well know you've talked about a lot. Adaptation physiologically happens as a byproduct of stress so you have to push the system so if you continue to do say the exact same workout over time. You better not expect much improvement you can keep maintenance but you're not going to be adding additional stress so in general you have to have some sort of progressive overload and we can talk in detail about what that means for each category but this could come from adding more weights this could come from adding more repetitions it could come from doing it more often in the week it could come from adding complexity to the movement so going from say a partial range of motion to a full range of motion or adding other variables so there's a lot of different ways to progress but you can. So if you have this kind of routine we built Monday Wednesday and Saturday or something and you just do that infinitely you're not going to get very far so that's I guess the most high level overview of all the things people can go after and then we can go from whatever direction you want. I love to do the deep dive on each one of these several hours but and I imagine that over time we probably will I'd love to chat about a couple of these in a bit more depth so in terms of defining what the progressive overload variables are for these different categories maybe we could hit the two most common combinations of these nine things the first one being. Strength and hypertrophy and maybe we could lump power in there maybe not you're the exercise is it is all yeah but strength and hypertrophy which at least bear some relationship yeah and then maybe separately we could explore sustained work endurance this 30 minutes or longer continuously because I think many people train in that regime yeah and probably something like the vo 2 max anaerobic as well because I know that a number of people now incorporate. So called hit or high intensity interval training I think with the hopes of either shortening their workouts yeah and or gaining some additional cardiovascular benefit so if we could start with strength and hypertrophy I know many people want to be stronger they want to grow larger muscles or at least maintain what they have yeah so what are the progressive overload principles that are most effective. Over time for strength and hypertrophy yeah okay so I'll actually go a little step back with every one of those categories I talked about you have what we call your modifiable variables so this is a very short list of all the things you can modify the different variables within your work out that can be modified that will change the outcome fancy way of saying if you do this differently then you're going to get a different result. So modifiable variables the very first one of those is called choice so this is the exercise choice you select now one of I'm going to go double back here so I'm kind of doing a little bit of inception so follow me here as I'm going up a layer to come down a couple layers. I have these fundamental laws of strength and conditioning that that I'll kind of like a little bit of a joke but progressive over those one of those laws another one of those laws is your exercises themselves do not determine adaptations. So here's what I mean if you're like I want to get stronger you can't select an exercise that doesn't determine you getting strong if you don't do the exercise correctly and I'm not even referring to the technique that of course matters but if you don't execute it in the right fashion then you're not going to get that adaptation so if you choose I want to get stronger I'm going to do a bench press well if you do the wrong set range the wrong repetition range the wrong speed you won't get strength you maybe get muscular endurance and very little strength adaptation so the exercise selection itself is important. But it does not determine the outcome adaptation so the very first thing that you need to think about if you're like I want to get stronger or add muscle is not the exercise choice right it is the application of the exercise what are the sets or the reps or the rest ranges that you're using that's going to be your primary determinant now some exercises are certainly better for some adaptations for example a deadlift is probably not a great exercise to do for long duration endurance like you could theoretically do 30 straight minutes of deadlifting but I'm not going to do that. So you're not going to do that for a minute of deadlifting but it's probably not our best choice right it's probably a pretty good choice for strength development right because you're going to do a little repetition ice at range. You could theoretically do bicep curls for power but probably not your best choice single joint isolation movement is is not the best for developing power even ever done a bicep curls fast as you possibly can like that's not going to go well so in theory any exercise can produce any adaptation given the execution is performed properly. is performed properly. So now that we've understood that a little bit, the exercise itself does not determine the adaptation. Coming within each one of these categories, exercise choice is an important variable because it does lend you to things like what movement pattern you're in. So in other words, if you wanna get stronger and you're thinking, okay, what exercise do I do? You need to think a little bit about what muscle groups do I wanna use? And that's gonna be leading you towards the exercise choice. For example, I wanna use my quads more. Okay, fine. Maybe you're gonna choose more of a front squat, type of variation of goblet squat. So the bar, the load is in front of you. If you wanna emphasize maybe more of your hamstrings and glutes, you're gonna maybe put a barbell on your back or do a different one. So the exercise choice is important to the prescription because it's gonna determine a lot of your success. Okay, another kind of simpler way to think about this. If you're a beginner or moderate to intermediate or maybe you don't have a coach, you probably wanna hedge towards an exercise selection that is a little bit easier technically. So you maybe don't wanna do a barbell back squat. It's actually a pretty complicated movement. Maybe you wanna do a little bit more of, again, a goblet squat or even use some machines or a split squat. Something that's a little bit simpler because you don't have a coach, you're not a professional athlete. The likelihood of success is higher and the risk is now gone lower. So the very first variable within all of these is the exercise choice. The second one is the intensity and that refers to in this context, not perceived effort. Like wow, that was a really intense workout. It is quite literally either a percentage of your one rep at max or a percentage of your maximum heart rate or a view to max. So for the strength based things, you wanna think about what's a percentage of the maximum weight I could lift one time. And that's what we're gonna call one rep max. Or it's a percentage of my heart rate, right? So if I tell you to get on a bike and I want you to do intervals and I want you to get 75%, I'm typically referring to 75% of your max heart rate or a view to max or something like that. If I tell you to do squats at 75%, that means 75% of the maximum amount of weight you could lift one time or close. In terms of determining one rep max, I confess I've never actually taken the one rep max for any exercise, but I have some internal sense of what that might be or what range it might be. Is it necessary for people to assess their one repetition maximum before going into these sorts of programs? No, not at all. I think a more intuitive way is to take a repetition range. Well, you could do this a couple different ways. So there are equations you can run and you could just Google these anywhere and these are called conversion charts. And so it says, okay, if I did 75 pounds on my bench press and I did it eight times, you can just run an estimate and say, okay, you're probably going to be able to bench about 95 pounds for one rep max or something. So that's a very easy conversion chart. So just pick a low that you feel comfortable with, but it's kind of heavy, but not like crazy heavy and do as many repetitions as you can, what a really good technique and then look what that number would be. So conversion safer than doing one repetition maximum. For the general public who has again, no coaching, it's safer for a professional athlete, it's not any safer, but or not even a professional athlete, but a trained person with a coach. But for most people, yeah, that's a good way to go about it. You can also just kind of do it with feel in the sense that say you want to do a set of five repetitions and you do the load and you think, I could have done one or two more. And then you kind of have an idea of what that number is going to be. If you think man, that last one, I had to kind of really, really, really get after it, then maybe just call that that number, right? So you don't have to get overly concerned. In fact, when we start getting into these number ranges, you're gonna see that they're all ranges. We're not gonna give a specific 95%. For one of these exact reasons, it's not that precise for most of them. In fact, some of them like hypertrophy have enormous ranges that you can almost can't miss. So the intensity in that case doesn't even matter for the most part because that's not the primary determinant. Some of these you're gonna see intensity is a determinant and some of these you're gonna see volume is the true determinant. So intensity though, is a second one. Choice was the very first manipulative variable. Intensity was the second one. The third one is what we call volume. And so this is just how many reps and how many sets are you doing, right? So if you're gonna do three sets of 10, that volume would be 30, right? Five sets of five, that volume is 25. It's just a simple equation. How much work are you totally doing? The next one, past that is called rest intervals. So this is about a time you're taking in between typically a set. Then from there you have progression, which is what we started to talk about this progressive overload. Are you increasing by weight or reps or rest intervals or complexity or whatever? So all of those things can be changed as a method of progression. And so maybe you wanna go progressing from a single joint exercise like a leg extension on a machine and you wanna progress by moving to a whole body movement like a squat. That and of itself, you don't have to change the load or the reps or the rest. That is a representation of progressive overload. And it's probably a pretty good place to start because number one, especially for beginners, you wanna make sure that the movement pattern is correct. Don't worry about intensity, don't worry about rep ranges or any of these things. You need to learn to move correctly and you need to give your body some time to develop some tissue tolerance so that you're not getting overtly sore. In general, soreness is a terrible proxy for exercise quality. It's a really bad way to estimate whether it was a good or a bad workout, especially for people in that beginner to middle, to moderate, in fact, even the vet for our professional athletes. We do not use soreness as a metric of a good workout. It's a really bad idea for a bunch of reasons. On the same token because stress is required for adaptation, you don't wanna leave it the gym and feel like, I don't really do much. There has to be there. So if you think about soreness on a scale of one to 10, you probably wanna spend most of your time in like the three. You mean post exercise? Yeah, in between workouts. Totally. And I know we'll talk about recovery extensively later, but if one body part or set of body parts is sore, is that an indication that one should stay out of training? I would imagine the answer is no. In most cases. And secondarily to that, if a particular muscle is sore, does that mean that muscle is not ready to be trained again? Yeah, the answer to both of those is the same, which is no. Right, you can certainly train a sore muscle. You need to, I guess, have a little bit of feel on that, right? So if you're a sore of like, okay, you're moving around a little bit and you're like, man, this is a little bit sore, you can train. If you're like, I can't sit on the couch without crying because my glutes are so sore, like we probably don't need to train again, right? We need to be... Does whimpering count is crying? Yeah, in that particular case, I'd say, you've actually gone to a place of detriment because now you're gonna have to skip a training session and now you're behind. So you're actually total volume, say across the month, is actually gonna be lower because you went way too hard in those workouts, had to take too many days off in between. You're gonna see that you're gonna cover less distance over the course of a month or six month or even a year. So you wanna walk a pretty fine line and for most people, I would say, hedge a little bit on the side of less sore than more sore because frequency is very, very important for almost all these adaptations. It's training frequency, which is the last modifiable variable, right? Frequency. Which is how many times per week are you doing that thing? So those are kind of our global things that we can play with. So when I'm trying to manipulate and you can get strength versus hypertrophy or you know what, I want like a little bit of both. All those variables are the things that are going through my mind. Which one do I need to move in which direction so that I can get this outcome and not this outcome over here? For example, some folks might wanna get stronger but not put muscle mass on. Some folks are just kinda want both. And that's a lot of the general public. I wanna get a little stronger and a little bit more muscle great. But there are instances where people for performance reasons or for purely personal preference like, I don't wanna get any more muscle great but I wanna get stronger. Awesome. If you manipulate those variables correctly, you can get exactly that. Very little development of muscle size and a lot of development and strength. And this is why we continue to break world records in sports like powerlifting and weightlifting that have weight classes. So there's a top number that we can hit in terms of body size but yet we continue to get stronger and faster. So this is very possible if you understand how to manipulate all those variables. So that being said, we can start off with, you wanted to go strength and that. Yeah, strength and I love that you mentioned the fact that it is possible to increase strength without increasing muscle size. Yeah. And it's not dramatically because I think it's not just weight class athletes. I know a lot of people who for aesthetic reasons, they'd like to be stronger. They're hearing that having strong bones and strong muscles and tendons, it's great for longevity and for avoiding injury and so many other features of life. And yet they don't want to fill out progressively larger and larger sizes of clothing. And we can go harder to the mechanisms on that piece if you want. And we can save that and come back to it. Sure. What I'd love to both, what I'd love to know was if we could define some of these modifiable variables in the context of strength. So let's say I were somebody who I come to you and I say, and let's just say for sake of balance here because she actually does do some weight training. I bring my sister in and I say, me and my sister both want to get stronger. What modifiable variables should, how should we modify the variables? Love it. All right, great. I'm going to do inception on you one more time. So one of my other laws, this won't be fast, I promise, of strength and conditioning is in general. The default is all joints through all range of motion. So this is important because it's going to answer you very first question on this strength category. So in general, the ankles should go through the full range of motion and the ankle. The knee should go through the full range of motion, the knee, the hip, the elbow, et cetera, et cetera, right? Across the workout, not in a single movement. Well, I would hope. Unless there's an amazing exercise I haven't heard about. Well, there are some exercises that we're going to call more full body, think about a full snatch. Like you're going to take a lot of your muscles, a lot of your joints through a lot of range of motions. Other ones like an isolation, we call these single joint exercises. So imagine a bicep curl. You have one joint in that particular case, the elbow moving, the shoulder and everything else is pretty much stable. And this is how we're differentiating multi joint from single joint movements. But yeah, so across, I would even say it doesn't even have to be the day, but maybe throughout the week, try to get every joint through full range of motion. Now, a couple of quick caveats to that. I am not advocating using full range of motion and allowing really bad exercise technique. So when I say full range of motion, that's the default. That doesn't mean every single person can do that for every single exercise. It means that's where we should be striving to and that's our starting point. You're going to see a lot less injury and a lot more productivity out of your training sessions. In fact, the science is fairly clear on this one. Strength development as well as hypertries generally enhanced with a larger range of motion of training. And the mechanisms are somewhat understood on that. So that being said, if you have to get into say a position with your say low back, the spine is a very good one. You're in general, the spine states very neutrals what we call it. So no flexion, no extension, especially in the lumbar region. So if you're doing say a deadlift and in order to take your knee through a full range of motion or deadlift, you have to compromise your back position. That's no point on. So caveat's there aside, don't kill me. Like in good positions. And don't kill yourselves more importantly. So why that matters is if we walk through strength, the very first thing I'm going to go through is the exercise selection. So let's choose an exercise which ideally has a full range of motion or close to it that doesn't induce injury for you that you can still maintain good neck and low back and position and everything else. You feel comfortable with so you can feel strong but you don't feel like, oh my gosh, I've never snatched before. Having you do a snatch for a maximum even 75%. It's a terrible idea. You're not going to feel confident it's going to be a train wreck. I would rather put you on a machine bench press. So even though I feel stable, I feel safe here and I can just express my strength. So exercise choice in general, in general, full range of motion. And you want to kind of balance between the movement areas. So this is an upper body press. So this is pushing away from you, bench press, things like that, upper body pull, pulling an implement towards you. Bent row, pull up. The pressing should be horizontal. So perpendicular to your body as well as vertical. So this is lifting away over top of your head, lifting away away from you. The pull version is pulling horizontal to you and pulling vertically down, pull up, things like that. From the lower body, we typically call these hinges. It's sort of a funny muscle thing that no one's going to laugh at like maybe me and you hear is we'll categorize muscles as our movements, exercises as pushers and pulls. So like a squat is tends to be push because you're pushing away the ground. A deadlift is a pull because you're pulling the implement up to you. But in reality, every single exercise is only ever a pull. Because muscle doesn't push things away. Muscle can only contract and pull on itself. And so again, super nerdy thing they like, most people are like, yeah, everyone's like, that's so dumb. No, but I think it's a really important point because it also speaks to something I think we'll get into later, which is that, you know, posterior chain anterior chain. Totally. And if that's mysterious to people, it'll become clear before long. Posterior chain anterior chain makes a lot of sense to me because of the way it's grounded in the firing of motor neurons, which is ultimately what controls muscles. So it's also I think nerves all the time. Exactly. So it also depends on the lens through which one looks at life and exercise, of course, my lens is primarily neuroscience. So what I realized that the importance, I like this idea of pushing perpendicular to the body overhead, pulling both toward toward the body and from overhead. That just makes really good intuitive sense, especially since a lot of people were just listening to this and not watching it. So in your mind, folks, you can think about pushing away like a punch or overhead, like lifting something overhead, and then pulling toward your midline or toward your body, rather, and then pulling yourself up like a pull up in PE class for those of the. So the lower body is the same thing, right? It's some sort of pushing away like a squat or a split squat or a lunge or something like that. And then some sort of, again, we'll call pull or hinge. So a deadlift or a Romanian deadlift or a hamstring curl or something where you're contracting and calling pulling the thing. And you could split these into like a thousand different categories. If you're really in that field, you're going to want to add a bunch of other ones. But that's just like a rough conception. So if you're going to do a single workout, you could choose four exercises. And you could choose one of each. One press, upper body press, one upper body pull, one lower body hinge, one lower body press. And that would be like a decently well-rounded exercise. That's your exercise selection. And if you're taking those three or four-range emotion, you're at a pretty good spot. There's a lot of things you can't. The next one is intensity. So if you want to develop strength, this comes back to one of my favorite sciences of all time. What happens to be a nerve guy, actually. And generally, I like to shoot on nerves as much as I possibly can, because I'm a muscle guy. But I have to give Hennamann some credit here. And I know you know who that is. Hennamann size principle. Yeah, of course. So this is a series of papers. I think it was a nature. At least some of them. Yeah. Yeah. In 1954, 1956, or something, you can fact-check me. I'm sure you will. But he basically outlined this idea that, okay, there's a certain recruitment threshold needed for neurons to fire. And we have muscle fibers in what we call fast twitch, muscle fibers in slow twitch, muscle fibers. And in general, you're going to activate the slow twitch on his first, because they tend to be associated with low threshold motor neurons. It's not exactly that way, but it's close enough, right? Well, the only way that you activate some of these higher threshold neurons is to demand the muscle to produce more force. And it's fairly specific to force, right? It's not something you can do over an endurance thing, right? Unless it gets really extreme and particularly happens. So in general, the only way to use these big chunks of your muscle, which are incredibly important for aging, by the way, one of the major problems we have with aging developing, or development of aging related issues with muscle, is the fact that we lose fast twitch fibers preferentially. And then we have major problems as we go down the line, because we've lost a big chunk of our strength in size. So you want to make sure these fibers stay alive and intact. Okay. So if that being said, the only way to develop strength is then to challenge the muscle to produce more total force. If you are fairly untrained or new, I guess I should have stated this all at the beginning as well. One more inception that I'll stop. When it comes to this level of detail of exercise prescription, a fairly untrained person is going to respond basically the same to every single thing you do. In fact, we've done this in a lot of many times. We've done training studies doing things like 30 minutes of cycling, and seeing huge increases in muscle strength in size, which is not a prescription for most people to increase size. But people that are really untrained, if you did plyometrics or strength training or endurance running, they all just get better at everything. So that caveat kind of aside, if you want to be more intentional and more specific to the goal of strength, you need to produce more force. Specificity matters, right? We have size principle to help understand this. And we have our laws of specificity, which say said principle, right? Specific adaptation to imposed demand. So the adaptation you get or the result of your training is going to be a reflection of the demand that you imposed. So if you want to get stronger, you need to impose a demand of strength, not repetitions. So this has to be, the load has to be very high. In general, you're probably looking at above 85% of your one-rat max, if you're moderately trained, maybe 75% will work lowly trained again, everything works. But in general, we want to be pressing a load that's very high. So because the intensity demand is so high, that is going to enforce you to do a low repetition range. You can't do 12 reps at 95%, then it wouldn't be 95% of your one-rat max. So by definition, true strength training is really going to be in like five repetitions per set or less range. That's where most of it's going to occur for specificities. So we've covered choice, intensity, and repetitions, right? The total amount of sets that you do is really kind of up to your personal fitness level, right? If you did as little as like three sets for exercise, that's probably enough. Work sets. Totally. Yeah, totally work sets, right? So get fully warmed up and build up to that 85%. Don't just walk into the gym and throw 85% on and go. Thank you. That's an important distinction. So work your way up. Do some, like a very classic warm up thing would be like a set of 10 at 50%, a set of eight at 60%, a set of maybe eight again at 70%, and then maybe like a set of five at 75%. So two or three or four sets, kind of building intensity and lowering the rep range, and then you would go after your two or three working sets. Also, in terms of rest intervals, now because we're trying to, the primary driver of strength is intensity. It's not the volume, right? It's the intensity. So in order to maintain that, we have to do a low repetition range. But in addition, we also have to have a high rest interval. Because if we start to, if we have any amount of fatigue in the curve, and we have to then reduce the reps or reduce the intensity, we've lost the primary driver. We've lost that main signal. So the number we're going to throw out typically is like two to four minutes. So imagine you did, you know, you're set a bench press, and you did five repetitions at 85%. You probably want to rest two to four minutes before coming back to the bench. That doesn't mean you have to sit there on your phone. Like, in fact, please don't. Everyone will thank you for not doing that, I promise. You can engage other muscle groups. This is what we call super setting. So you're doing your bench press, and while that two minute clock is running for your chest to rest, you can go over and do your deadlifts. And so, you know, you can kind of move back and forth, and this is how you can make strength training at not seven hour workout. If you're a professional athlete, you're going to take that time, because you want to maximize the outcome. We've done this actually in our lab two. Super sets will reduce the strength gains, but by a tiny amount. And most of us don't care enough. Relative to, it's going to triple the length of your training session. It's not worth it. So for the average person, I will tell them, yeah, super set. For someone who's trying to break a world record, and weightlifting or powerlifting, I don't super set. Interesting. Yeah, I think I've found that, I don't recover particularly well from strength and hypertrophy training. So, I like in the workout or the next one. From workout to workout. Unless I keep the total duration of those workouts, I like to say no more than 60 minutes of work, of real work. Yep, yep. Maybe 75. Past 75, I find that I just start to, I have to introduce additional rest days, or I just get weaker over time. So I set a limit at 50 minutes, and then I usually violate that limit. And then I'm doing 60 minutes. So I'm excited to hear that one can super set exercises, as long as they work different muscle groups, of course. So I wouldn't want to do bench press and overhead press super set it, because we can eat, I think that's those without saying for most people, but just to point it out. But that I could do some push pull, push pull, without compromising total intensity that much. And I certainly would be willing to give up a rep here or there, or a few pounds here or there. And may ask whether or not in doing that one gets any, even tiny bit, or more of additional benefit in terms of cardiovascular work, because I imagine after all, even a one rep max, which I've never done, as I mentioned, but let's say I get three reps on the overhead press, and then I get four reps on a weighted pull-up, and I'm going back and forth. No doubt going to be breathing harder than if I was sitting there texting away on my phone in between sets. Yep, of course. Yeah, and in fact, in general, one of the things that I'll present in my class is a giant list of, in fact, on the top is all these different exercise adaptations I started the conversation with. And on the vertical column are, as many of the physiological potential adaptations one would get. So changes in endogenous pH, blood pressure, lymphatic changes, bone density, all these things, right, and you can run a matrix, and you can start to look at, okay, if I do speed training, am I going to see changes in the nervous system? Well, like very much so, right? That's the primary act of reason those things work. Very little change in the muscle system. And that's just exclusively explained by the central or peripheral nervous system, right? On that same token, are you going to expect many cardiovascular adaptations from speed? And the answer is no, because, although we didn't cover it, speed is very low intensity, very low rep range, very high rest. Well, as you go to like strength, and then you go to hypertrophy, you start seeing more and more increases in cardiovascular adaptations because you're doing exactly that, right? You're starting to reduced rest, and you're starting to increase volume. But you're going to lose things like bone mineral adaptations, because the load serves to go down. So you can look at this matrix and kind of understand, if I'm a person who wants to kind of maximize the adaptations I get across my entire physiology for the least amount of work, you can choose these different adaptations to go after that are going to kind of land on these things, right? And exactly as you mentioned, if you're going to take five minutes for rest between each rep, so let's say the extreme, you're going to do three sets of one repetition for strength, that 95%. You're going to take probably five, maybe seven minutes, between each attempt. Like you better not expect many changes in your resting blood pressure, that there's no cardiovascular strain there. You're going to put it together in a circuit, where you're going to lose some potential strength adaptation, but you're going to gain something there. So all these things are, it's not about good or bad or right or wrong. It's always about what advantage you want, what disadvantage you want. And I can cut really end to the chase here on one of these things, because we'll get to this eventually. If you want to know the ones that are going to generally give you the most physiological adaptations across the most categories, you're almost always looking for a perch-be-type of training, and then this anaerobic conditioning piece we're going to do, that's going to hit the most systems at once. That's great to know, and we should definitely go a little bit deeper on those types of what the modifiable variables are for those categories, because I think that I'm guessing the vast majority of people want to be a bit stronger, maybe add some a little bit of muscle or more, make sure their heart is healthy and et cetera. This is wonderful, and I think is clarifying certainly a lot for me. So for strength, let's, I guess, training frequency. Frequency. So what should determine training frequency? And I had the great benefit of a long time ago when I was in high school, actually, I paid for a session over the phone with Mike Menser. Oh, you know, Lee Mike Menser. We have to be friends over time. I had a great time. At the time I was pretty young and my mother kept saying, like, why is this like grown man calling the house? I mean, we would talk all the time about training, but he tried to convince me to train once every five to seven days, very few sets, very high intensity, and I must say it worked incredibly well. Sure. It was, I think with my recovery quotient, which was not very good, I think has improved over time. It was not very good. It was remarkable. But of course, this was a time when I was, you know, full of the most animalism I've ever had on my own version of anabolic. Sure. I was, you know, really had a long arc of puberty. And you were untrained. And I was mostly untrained. I've been running across country and skateboarding and playing soccer. And doing all the things that are like the antithesis of great muscle. It was literally, and people will probably say impossible. It was something like 40 pounds of muscle inside of 12 months. It was crazy. I would believe it. But, and so then of course that stopped working over time. And then you start going down the, the, the odyssey of trying to find the thing that's going to work that well. And you eventually realized that it was because you were untrained, right? So training frequency is, is crucial. Let's say that people are doing these whole body workouts as you describe them. Not alternating upper body lower body, because there's so many different splits that we've talked about. It doesn't probably doesn't make sense to go into splits in, in, in, right now. But how often can, can and should one train a muscle? And how do you know if a muscle is recovered locally? And how do you know if your nervous system is recovered systemically? Okay. This is a bunch of really interesting questions. I'm not sure exactly what right you want to go. So I'll start here. As I mentioned earlier, soreness is not a good parameter of exercise quality. Because some types of training are going to induce more soreness that are going to induce less. That's important to this conversation because when you ask about how do you know if a muscle is ready to train again? One of the questions is what are you training for? If you're training for hypertrophy, right? Muscle size muscle growth. We need to hedge towards recovery. Because what you're trying to do is cause a massive insult there, allow then protein synthesis to occur, building of new tissue, which takes time 48 to 72 hours, like kind of about a minimum, that process needs to occur. If you're doing actually more strength, and this is a differentiation between hypertrophy and strength, then you didn't induce actually much damage. In fact, you're generally not going to get very sore from true strength training, very little, unless you get really heavy, you did a lot. The primary driver of hypertrophy is not the same primary driver of strength. We talked about that already. That's intensity driven for hypertrophy. It's not intensity. So because we have different mechanisms, we have different outcomes, even though they're closely aligned. Strength is not going to cause a lot of soreness. Therefore, intensity is the driver. Therefore, frequency can be as high as you want. So you can train every single day, the same exact muscle, if speed or power or strength, are the primary training tools. Because you need stimulus there. Skill is well, right? Practice. That, you know that, as much as anybody, developing a new motor pattern requires a lot of repetitions, right? You don't need a tremendous amount of rest. That's not a damage thing, right? It's a repattering issue. So strength training, in fact, if you look at, again, true strength professional athletes, they're going to train the same muscles basically every day. Wow. They're going to squat every day. And is that because the primary mode of adaptation is recruitment of these high threshold motor units? So it's mainly neural. No. So everyone's going to say that. And this is where I get all feisty. Well, I'm not saying that. That was actually, there was a question mark there. Okay. Okay. Okay. Okay. If we were online putting comments, we, there would be a question mark. We would have fought. I would have blocked you. I'll just keep it. That's how you already blocked. No. Probably twice. Okay. The early adaptations to exercise, especially strength training, are hedged towards the nervous system. No question about it. People obviously have central nervous system, but it's probably more peripheral, right? Whatever. Semantics probably, but pedantic. It's nerve. If you train today to more and more, you're not going to wake up with a actually increase in contractile proteins and muscle. Your muscle might be a little bit bigger due to some acute swelling. But you could have an, and a pretty acute that persists, change them. And the nervous system will call it that allows you to be stronger like within a couple of days. Sustained hypertrophy is probably more along the lines of four weeks. Or we can see that, right? We can actually see changes like in the ultrasound. Now, you're making changes immediately. That protein synthesis process is happening like very fast. And it's going to last. It just takes us time to measure it in terms of a noticeable change in your whole muscle size. So that being said, the first four weeks we typically say are primarily nervous system. After that, now we're starting to see most of the changes coming from the muscle side of the equation. So with strength development, it's a combination of three areas. In fact, all muscle contraction has these same three things. It starts off with some signal, right? From somewhere in the body, whether it's all the way up the top or at the level of the spine, depending on if this is a reaction or an actual conscious control. From there, that some signal has to tell the muscle to contract. Okay? So signal is one, two, it's muscular contraction. And there's a lot of variables inside the muscle tissue itself that determine its functionality. And so if we took an individual biopsy and took a muscle fiber from you and took one from me, and we took those muscles out and put them in a petri dish. And I tied one end to a force transducer, and the other end to a thing that pulls it. And we soaked it in a bath of calcium and a bunch of other stuff. Even if they were the same size, your fibers might contract a lot faster than mine, even relative to size, or not, or slower, or there's various properties. So the intrinsic fibers themselves determine a lot of functionality. From there, muscle fibers don't cause movements. Muscle fibers simply contract. They're all surrounded with connective tissue. And that's all surrounded with a bunch of more connective tissue. And that all surrounds into a muscle. That muscle is in surrounded with more connective tissue. That all comes together into a giant tendon. That tendon attaches to the bone. It's pulling on those tendon that actually move the bone that causes human movement. So that's area three. Area one, the nervous system area two, the muscle contraction area three, some sort of connective tissue thing. Change has happened at all three of those levels. And we're not even now talking, well, even you entered the discussion of biomechanics. And you changed, say, the penational angle of the muscle, which is the angle at which the muscle fibers lay relative to the bone. So this is basic mechanics. Is it pulling perpendicular to the bone? Is it pulling horizontal to the bone? Or some sort of angle? All of these things determine human performance. So when you're talking about, again, that strength development, you can see tremendous improvements in total force production by manipulating all of those areas. And you have not touched changes in muscle size. If you change muscle size in a true sustained fashion, whether this is circumplasmic or to contractile proteins, you have given yourself more opportunity to produce more force. It doesn't guarantee you produce more force. Bodybuilders are not stronger than power lifters, even though they have more muscle. But bodybuilders are probably stronger than most people. So there is a relationship between muscle size and strength. It's in this not a one to one guaranteed ratio. And that's generally because the, although the muscle has been aided, they may have not changed the biomechanical considerations. They may have not changed the connected tissue, nor the nervous system stuff. And so that's why we see this giant relationship. That R value is pretty high between strength and hypertrophy. But if you really want to get to the ends of it, it's not. And that matters to your actual question ten minutes ago. Because again, you can train strength daily on the same muscle. But if you want to allow for that process of connect, contractile proteins to add and grow, then you're going to have to allow some recovery. Because if you go back into that muscle too soon, you're going to blunt the response, you're going to stop it, you're going to cut it off. You have all kinds of problems going on in the cell that are going to just attenuate that growth response. So I gave you the answer for strength training. The answer for hypertrophy is probably less than three out of ten on level of soreness, so you can go again. In general, you're probably looking at 72 hours is the optimal window. So if you trained your, your shoulders on Monday, you probably would don't want to train them again on Tuesday. If I hypertrophy is the goal, maybe Wednesday, maybe Thursday's best. So something like an every two to three day window is probably, and we know a little bit more now about why that is. The gene cascade, the signaling response happens, well, the signaling happens instantaneously, right? Within seconds, the gene cascade is probably in the peaked in the four hour window, like depending on which gene you want to look at, but it's just kind of a snapshot. But the protein synthesis process is 24 to 48 hour thing. And so it tends to kind of look like let that thing finish and let that signaling go back to baseline, and then head it again. And then head it again. And now as long as you're providing the nutrients, the recovery should happen, and you should be able to sustain the same work output in the training session. So the stimulus stays high, and the recovery is there, and you can now continue to grow muscle. You mentioned 48 to 72 hours for hypertrophy. What if, for whatever reasons, the training split, lifestyle factors, et cetera, somebody say, let's use your example, trains shoulders on Monday, ideally they would train them again on Thursday in their particular instance, somewhere Wednesday or Thursday, but they don't. They wait until Saturday or Sunday for whatever reason. Maybe it's more compatible with their work, work, work, and other exercise schedule, whatever the reason, are they actually losing hypertrophy that they gained or they've missed a window to induce further hypertrophy? It's probably better to think about it the latter. It's not that you've lost. It's just you've just kind of lost an opportunity to make more progress. I will save you a little bit, and kind of going back to your HIIT program, this is the original high intensity training that the men's are thing, right? Which is not... The HIIT with one eye, not the high intensity interval training, but high intensity training. Like one set to absolute failure, maybe two for each muscle group. 20 minute workouts. Dividing your body into three into a three way split, and then literally training... Matching. Six times a month, which most people think that is absolutely crazy. There's no way that's going to work, and I can tell you... It does. If you are untrained, you grow like a weed. Just if you train hard enough. Even if you're trained. Look at the people who might trained. He put a lot of bodybuilders on really high levels. Now, they had the same similar help you had at that time frame. Wait, to be very clear, I was not taking exhaustion and Santa box. In fact, I was... But your endogenous was just as good. I probably was. I wasn't measuring my levels there, but I probably would. I grew easy. And in general, I tend to grow pretty easily from weight training. But the... And I should say that to Mike's credit, and I think this is an important message, that he was the one who really said, look, unless you're going to make a professional career out of it, do not run the health hazards of exogenous hormones, it's certainly not at your age. So he deterred me from that, which was great, because it never entered my mind. It just was one of those things where Mike Mencer said, don't do it, and he had clearly done it. Right? And so he's speaking from an informed place. It never entered my mind, but also I was what was really wild as I was continuing to run across country. And so there was a tradeoff there at some point. A little bit of an inter-inter-inter-execence. When you're young, you can get... Many people can get away with... Totally....with what at this age would surely place me into a state of overtraining even at low volume. Well, see... Yeah. Well, I mean, like the whole field on interference effects has changed quite a bit recently, which we could come back to if you want. But just to finish out the idea here with that last question. If you want to take five days or six days in between each muscle group, you can do that. In fact, if you look at the research, it's going to show that frequency is not that important. Well, it's not that it's not important, but it's... It can handle changes. As long as you get to the same total volume. So you can do that. You just have to do a lot more work in that one workout. If you care about the six week, eight week, thing, if you're like, I'm in this for the next 60 years, it's probably okay, right? But it can be there that the challenge with splitting up your training sessions for hypertrophy into smaller numbers, like once or twice a week, it's just difficult to get that number. It's typical to get that volume done. Volume-wise, the more recent meta-analyses are going to say that you're probably looking at around 10 working sets, per muscle group per week. It seems to be kind of the minimum threshold that you're going to want to hit. So if you did three sets of 10 at your shoulders on Monday, three sets of 10 shoulders Wednesday and three on Friday, that's nine working sets. If you wanted to do three different shoulder exercises on Monday and hit your nine sets, it's not really actually going to be that much different. The problem is, 10 is kind of the minimum. You probably want to look for more like 15 to 20 and in fact, well-trained folks, 20, 25. That becomes very challenging in one workout. In fact, Difonkle, you're not going to be able to do it. And so that is where it's not the frequency that looks like it kills you. It's just the fact you have got to get because a total driver of strength is intensity, but the total driver of hypertrophy is volume. Assumes you're taking it to fatigue, right, or a muscular failure. So it's just tough to get enough done. If you can, and if you want to set your schedule up that way, like you probably remember, if you do those types of training sessions, where you're just going to completely exhaust a muscle, it's going to be tough. It's going to be so for a while. You're probably not going to come back. And that's sort of the logic behind that was, let's take this thing to tremendous failure and give it six days to recover. It can work. It's just not the best. I think there's a one way to think about it. For most people. It's also hard to do those workouts without a training partner. If you really want to do them correctly. And stimulants and headphones and all kinds of other things. Yeah, well, anyway, yeah, stimulants are not, I don't certainly don't recommend those. Yeah. Maybe a cup of coffee or two if that's your thing. But, and maybe some of the safer supplements. But certainly not, the sorts of stimulants that the guys in the 70s and 80s were saying, or still use. No way for still use. Or still use. You talked about repetition ranges, broadly for strength training. So five or less. Yep. You said frequency could be as often as every day. Yeah. Rest two to four minutes. Maybe even longer if you're going for one repetition maximum. Yeah. For hypertrophy. Sure. What are the repetition ranges that are effective? And what are the ones that are most effective if one is trying to maximize some of the other variables? Like people don't want to spend more than an hour to 75 minutes in the gym. Because I think that while the rep ranges might be quite broad as you alluded to earlier. There's the practical, there are the practical constraints. Yeah. So what repetition ranges or percent of one repetition maximum? Should people consider when thinking about hypertrophy? Right. The quick answer there is anywhere between like five to 30 reps per set. That's going to show across the literature pretty much equal hypertrophy games. And we can have a really interesting discussion about why that is. But I'm just remembering one thing from a second ago. I want to give a better answer for the frequency. You can do every single week for strength or every single day for strength. If you want though, like what's probably minimally viable to twice per week per muscle. So hamstrings, strength, twice per week. That's a good number to get most people really strong. Okay. You can do every single day. You don't need to though. So I want to make sure that like I wasn't saying you have to train a muscle 85% every single day to get strong. Two is a good number three is great. But probably even two is really effective. Got it. And this explains the high frequency of training for strength athletes that's always mystified me. And the very long workout to make sense because very long. They're not even trained twice a day. Even the morning squat in the afternoon every day. With their eating and their sleeping, they probably don't have time for anything else. That's why they're pros. So that's a job, right? That's what they do. So yeah, your hypertrophy. Strength training programming is somewhat complicated. Because of that's not the danger. But you're going to have to pay one way or the other, right? The risk is a little bit higher because the load's higher and you have to be a little more technically proficient. When it comes to hypertrophy training, the way I like to explain it is it's kind of idiot proof. The programming is idiot proof. The work is hard though. So you're here's your range anywhere between five reps and 30. Can you hit somewhere in there? Perfect. It's all equally effective. You can't screw that up. The only caveat for hypertrophy is you have to take it to muscular failure. And you need enough rest for the adaptation and protein synthesis to occur. Yep. And if you recover faster, you can maybe do it more frequently. And if you don't, maybe less frequently. By that logic, should people perhaps experiment and figure out what repetition range allows them to recover in concert with the training frequency that they can do consistently? My recommendation is I think you should actually set your use the repetition range as a way to have some variation. Because most people don't want to go into gym and do three sets of 10. They're going to get very bored very quickly. And so I think you should actually intentionally change the reps schemes for simple sake of having more fun. It is a very different challenge. The mechanisms that are inducing hypertrophy are different. But there's only a maximum amount of growth that one can get. And so you have as best we think it now. And some people actually will dispouse that we know really clearly about the mechanisms of most hypertrophy we don't. It's still very much a guessing game. But the three most likely drivers are one metabolic stress, two mechanical tension, and then three muscular damage. You don't have to have all three. One is sufficient. You can have a little bit of one or two. And you can cut it. So you get it to play here. We've already talked about the muscular damage. Again, it's very clear. More damage is not better. But it is somewhat decent proxy. Like it's getting a little bit of soreness is good, you don't get so sore it's compromising your total volume. Mechanical tension is kind of like strength. This is why if you do even such a five or eight and you're kind of close to that strength range, you will gain a little bit of muscle. Not optimal muscle gain, but you're going to gain some because everything in these physiology isn't cut off at four reps. And then five reps is a different thing. It's always a blend. So think of it as like a fading curve. And you get closer to the end, it fades less effective as you get closer to the middle. It's more effective. Anywhere between eight reps percent to 30, it's equally effective. Past 30, it's going to blend out. Past eight to five to four to three, it's going to blend, you know, less or there. So metabolic stress is one. The damage is the other or sorry mechanical tension is the one that's heavy. Muscle damage is the one. The third one is metabolic stress. And this is a bit of an area of scientific contention, but something's there. I know something's there. We're just kind of fumbling to figure out what exactly it is. And this is metabolic stress is the burn, right? It's there. It's why blood flow restriction training probably works. That's done very light. So there's no mechanical tension. There's very little damage. But somehow it induces a good amount of hypertrophy. Very painful. Oh boy. I tried this, I've a friend former special operator who was on the east coast and took me through a blood flow restriction training protocol in the park. And I don't think I actually cried. But you probably did. But I might have cried out once or twice. It was unbelievable, especially the lower body movements. Yeah. It was a humid day. I'll clean a little bit of jelly. No, no. It was brutal. It was really brutal. It was also the best of your life and it's still brittle. Okay. Well, that makes me feel a little bit better. It was intense. And people should know that it is important to use the proper cuffs for these things. I don't have any relationship training, the companies that sell these cuffs. But the reason is that you actually need to block particular avenues of blood flow. You can't simply cinch off a muscle. You can't turn it get a muscle and train. You can actually kill yourself that way. Yeah, you can get a blood clot. Yeah. And so if you're interested in blood flow restriction training, I imagine you have some content about this or will it? At some point, but also there are resources online that people can pick up. Yeah. Yeah. A question about hypertrophy training that I think many people are wondering about. Train to failure or don't train to failure. Assuming good form. Yeah. Okay. Assuming good form. Great. The answer is both. So you want to train to failure, but you don't need to go to extreme failure. So you don't need to necessarily go to that like. A partner has to lift the barbell off my chest, but you have to get close. You have to drive either heavy. Stress, damage, right? Or pump. And so I really easy practical way to think about this. I heard Mike Gzerre tell runs a company called Rezness Noss Periodization years ago, outlined this at an NSEA talk. And it was beautiful. And I thought this is the most eloquent way to explain the context about training for hypertrophy. So I want you to look for three things in your workout. And let's say that you have a particular muscle to grow. Let's say you want your glutes to get larger. Okay. When you're doing your glute exercises, number one, are you feeling the glute contract? Okay. It doesn't have to be there, but that's a good sign if it is. Okay. Let's say I didn't really feel my glute contract. I felt it more in my quads or my back. Okay. Did you feel a big pump afterwards? No, I didn't really feel a pump there either. It's ordering. Okay. Great. Number three. Did you feel a little bit of soreness there at all? No, I didn't. Well, that's a very good indicator. You didn't feel it during the workout. You felt no sort of pump and it didn't get sore. Don't expect much growth. Did you just... You just tripped it did the work across a bunch of muscle groups. Most likely other muscle groups were too involved, right? Especially if you're like, no, but man, my back got released. Well, that's a really good indication of telling you what the hell was moving. And so in terms of targets, if you were to put, I get a one to, you know, 10 scale. How much should I feel it burning during? Anything less than a three. Okay. It's probably not doing much, right? But it doesn't... Like seven is not... A 10 is not better than seven. You need to feel it, but it doesn't have to be like, oh my gosh, I'm dying here. Soreness, same barometer, right? So if you can get like three, three, and three, you're probably in a pretty good spot. Five, five, and five is maybe better. But you don't need to go much past that. So I want you to feel the muscle group either working. Or if you're like, I didn't feel it much. I didn't really get a pump at the next day. It got really sore, then you're still, you know, on a good path. Again, really sore is in like, ooh, a little tender, but next day it's okay. They have to that, I could train. No problem. That's really what you want to go after. And in terms of understanding, is this likely to produce some growth or not? Excellent, excellent. Very clear parameters and recommendations. I know are benefiting me and will benefit a lot of people. If you'd be willing to throw out a few sort of sets and rep parameters that could act as broad guidelines for people who want to explore further. I realize that with all these modifiable variables that there's no one size fits all four strengths. I love this five to 30 for hypertrophy. That's the bottle thing. I don't think I've ever done a 30 rep set of anything. But now that you've thrown that out there, I see it as a bit of a challenge. You want to know it's awesome about 30. You're going to get an insane pump. You're going to burn like crazy, but you won't get super sore. Because I'm kind of attention to the low. It's so light. You can get away with those things. It's hard because your mind is going to wander. You're going to get it like rep 20. You're going to be like, I'm done. And you're like, no, there's a lot left here to get 30. Where a set of 10 is much easier. You're like, you just like, okay, two more, two more. So 30 is like, I got 16 more. It's awful, but you're not counting as work. It's terrible. People tend to just kind of like checkout. So 30 is possible, but a little bit extreme. But I would recommend them all of them. It's a really fun play. You can do the different in the same workout, too, by the way. Like you could do one set of 10 pushups and then take a little break and then do a set of 25. You can mix and match these things. There's no magic recipe that has to happen for all those. Or do it different. So Mondays are my sets of 10 days. Wednesdays are my set of 20 days. And Fridays are my set of 30 days. And you can have all kinds of fun there. And it's hard to screw up. Great. That phrase is always reassuring. So for strength, is there a set of reps protocol that is pretty sure fire? So a way to just think about a really fast answer for power, will speed power and strength is what I just call the three to five concept. All right. So pick three to five exercises. If you're feeling better that day, choose in the higher end. If you're feeling less that day or you have a shorter time frame to train, go less. So this would be three sets or three exercises or other or five exercises most. So three to five exercises. Do three to five reps. Three to five sets. Take three to five minutes rest in between and do it three to five times a week. So that can be as little as three sets of three. For three exercises, three times a week. That's a 20 minute workout three times a week. It can be as high as five sets of five for five exercises five days a week. So it's very broad and allows people to still stay within the domains of strength and power. While still being able to move and contour toward their lifestyle and and so on as and time and all those things. The only differentiator to pay attention to between power and strength is intensity. So if you want strength, this is now 85% plus of your max, right? If you want power, it needs to be a lot lighter because you need to move more towards the velocity into the spectrum. Because power is strength multiplied by speed. So while getting stronger by definition can help power, you probably want to spend more of your time in the 40% to 70% range, like plus or minus. So that's it. Both of them conceptually they'll work everything else. The exercises, the reps, the frequency, all that can be still in the three to five range. Just change the intensity depending on which outcome you want. The nervous system obviously plays an important role at the level of nerves controlling the contraction of muscle fibers. But of course we have these upper motor neurons, which are the ones that reside in our brain that control the lower motorones that control muscle. And this takes us into the realm of where the mind is at during a particular movement. And to me, this is not an abstract thing. I can imagine doing workouts that are mainly focused on strength or mainly focused on hypertrophy. And in the case of strength, am I trying to move weights? And when I'm trying to generate hypertrophy, am I trying to quote unquote challenge muscles? In other words, if I'm just trying to move a weight away from my body, you know, pushing a bench press or an overhead press, I don't know that I want my mind thinking about the contraction of my medial delts. I think I want my mind in getting the weight overhead with the best proper form, best excuse me, and proper form. And certainly with hypertrophy training, best improper form is going to be the target as well. But that simple, or I should say subtle mental shift changes the patterns of nerve fiber recruitment. So can we say to get stronger focus on moving weights still with proper form and safely and to get hypertrophy, focus on challenging muscles still with proper form and safely? It's very fair. Yeah, as a snapshot answer, it is a very fair thing to think about. Intentionality matters for both. In other words, if you look at some interesting sciences been done on power development and speed development, the intent to move is actually more important than the actual movement velocity. So if you're doing say something for power or strength and you're doing just enough to get the bar up, that will result in less improvements in strength, then even if you're moving at the exact same speed, but you're intending to move faster. And this is one of the reasons why good coaching matters. So if you're coaching an athlete through a power workout, especially, and they're doing enough to just lift 50% of the one right max, it's not going to generate as much speed development as them trying to move that bar as fast as I can't even if the net result is the same bar velocity. Turns out nerves matter. That's it. I mean, I was about to say amazing, but it's a neuroscientist. If I say amazing that nerves matter, what's amazing to me is what if I understand correctly what you're saying is that even if the bar is moving at the same speed, same weight. If my internal representation, my thoughts are I'm trying to move this as fast as possible versus I'm just trying to get the bar away from me and get the weight up. I'm going to get different outcomes. Yep, this is quality of work, right? This is, did you do enough to just check off the box or did you actually strive for adaptation? Similar concept actually works right peritrophy in terms of there is a handful of very recent studies that have looked at what we call the mind muscle connection. And this is doing things like imagine a bicep curl and you're simply looking at and watching your biceps and you're thinking about contracting it harder, even though you execute the same repetitions at the same exact intensity. Initial indications are the mind body connection are going to result in more growth than not. You just gave authorization for people to look at their muscles contracting in the gym. Please do. Yeah, of course, right? But the selfie is still ruled out. I'd rather you look at your muscles in your phone. So I'm fine with it. Those are initial. We don't have a large depth of research to support that. Maybe some stuff will come encounter it. But it does it matches what folks in that community have been saying for a very long time. There's actually some stuff on simply flexing in between. So if you've ever seen a bodybuilder, they'll do their set of bicep curls and then they'll get out in a flex and check. And they're literally, this is what Arnold did, right? This is if you go back to pumping an iron or college weight rooms, I should say. For some reason, there's something about that age group. Yeah. There's a lot of checking of biceps in college weight rooms for reasons that escape me. If you ever interact with my wife, she will be the first to tell you I cannot walk past a mirror without like checking something out. You can't do the she can't. I can't. Not her. Me. I'm going to cannot walk past. All right. Well, then I'll be careful not to disparage that. And I have nothing to do with the hypertrophy, but I'm just like, I'm a muscle guy. So I'm always like thinking and tinkering or whatever. But yeah, it is, I think it's very much worth your time to do a higher quality training session. Be more intentional. Be present. Then just execute in the same exact workout. I think that's globally very clear to be to your advantage. So if you're thinking, like, I'm going to, like, I don't want to work out today. I got all this going on or I'm tired or whatever. I'm just going to do the workout anyways and get through it. Okay. If you can go, you know what, though, like I'm going to cut 15 minutes out of this thing. I'm going to get my head right. I'm going to go to 20 minutes of quality work done. That's, that's your best option by far. You alluded to the fact that even just looking at a particular muscle might benefit in terms of the number of people. In terms of the number of fibers you can recruit or it's potential for hypertrophy. I've heard before and I certainly have experienced that muscles that, for whatever reason, genetics or sports that won't play it, etc. Muscles that we find that we can contract to the point of almost a slightly painful contraction seem to grow more readily than muscles that we can't recruit very easily. And there, and the reason I mentioned sports that we played earlier is I mean, you just have to watch the Olympics to see that, you know, swimmers obviously are very good at engaging their lats. You look at the gymnasts, they seem to be very good at engaging everything. And they go through a huge number of different dynamic movements that explains that. So I find that, you know, if people say, oh, you know, I can't get stronger in this or my whatever body part is weak in terms of it. In terms of it, it's inability to engage hypertrophy that oftentimes that can be because of an inability to engage those upper motor neurons to deliberately isolate those muscles. Are there ways that people can learn to engage particular muscle groups more effectively over time for sake of hypertrophy or strength or for cases of trying to overcome injury potential or injury because imbalances are bad across the board. And this is actually very common. And I think everyone has probably gone to this. There's some part that you just can't get going for me. That was the lats. That was a rhomboid. So my back muscles for years, I couldn't activate my lats or my rhomboid. These are the muscle groups that connect or shoulder blades. So if you try to squeeze your shoulder blades together, that set of muscles there, I call your rhomboids. Your lats, of course, are more vertical and pull you kind of up and down. No matter how many lap pull downs I did, bent rows, pull ups, I never see any development there, no increase in strength. And it took me probably a decade to figure out how the hell to actually get these things on. In fact, if you would have asked me, even in my college years as a college football player, hey, flex your lats. Like show me your lats, you would have seen no movement there. When I was doing a pull up in that particular case, the only way I could get the bar to move was by using my biceps. So it's a synergized muscle. It was supposed to be a secondary tertiary muscle in that movement. But for me, it was primer because of my over strength in my biceps coupled with my lack of activation in the lats. So you're compensating the same movement. Actually, kind of an easy way to think about this is, imagine doing a bent row. So imagine your bent over kind of at a 45 degree or a horizontal angle and you're going to pull a barbell to your belly button. Now, you can actually do that exact same movement with very little back muscle activation by simply flexing your elbows more. And so you think the barbell is going all the way down, it's coming all the way up to touching my belly. And you think you're doing a great back development exercise. In fact, because of the way that you're executing the movement, you're getting very little back development. And this is a really good example of why someone has done a specific exercise many, many, many times, be at fail to see development in a muscle group. Which goes back to earlier part of our conversation, which is why exercises themselves do not determine the adaptation. It's the execution that matters, right? It's the technique, it's the rep range. All of those are going to determine your actual result. So if any time you were you're banging your head against the wall and thinking like, why am I not getting movement here growth or strength or whatever, it's almost one of those, it's guaranteed to be one of those areas, right? You're probably not getting the muscle groups to activate in that particular example, just because we're here. Try imagine doing that bent row instead of pulling the barbell to your belly, squeeze your shoulder blades together first as far as they can possibly go. And then bring your elbows up without changing the angle of your elbow. So in other words, without bringing your hand closer to your shoulder. So keep that same angle and come up as high as you possibly can and then finish out the movement. That's going to guarantee a utilization first of the back muscles and a finishing with the biceps at the end, which is how that movement is supposed to go. So how do you coach into that? Well, it can be a number of things. Whenever I'm diagnosing movement quality, I look for a handful of things, but very first one is awareness. You'd be surprised how many folks, when you just simply tell them that muscle group right there and maybe you give them a tactical prompt, so you touch it or you put something against it. This is actually why, sorry, I'm jumping over the place, but this is why things like a belt work very well for actually increasing abdominal strength. So a misconception out there is if you wear like a belt when you're lifting, then the belt kind of does all the work for you and your abs get weaker. That can happen, but the exact opposite can happen as well. So if you take a belt, for example, and you cinch it down really tight, and then you just completely disregard your midsection, you will see a loss of strength in your midsection because not a belt is doing the work. But if you put the belt on just a little bit, kind of tight, where you get some sensory feedback and you think about using that belt as a way to activate the core musk mixture, you will actually see a higher. And if we look at like EMG activation, the core muscles would be activated higher to a greater extent than when the belt is off because of proprioceptive feedback. And for those that are wondering what proprioceptive feedback is, proprioceptive feedback is that there are nerves that extend out to the muscles that control muscle contractions, but then there are sensory inputs from the skin and muscle that go back into the nervous system and those work in concert and that that feedback is proprioceptive. I think it literally translates to a knowledge of where ones limbs are and what's happening on those. I've seen, I don't have a training partner, but I've seen in gyms where someone will be training and someone will tap the muscle of the person who's doing the work in order with this is consensual tapping of other people's muscles not walking around you, touching people's muscles, please. To provide that proprioceptive feedback so that the person doing the exercises, it becomes more aware of the muscle that they're supposed to be training and it seems that that's probably an effective practice. Yeah, I'll give you two examples. I'll go to the back with that pulling movement and then I'll stay in the belt really quickly. So a very easy example that you can do right now, listening and I learned this from Brian McKenzie or mutual friend. If you take your hands and open them up, like you make an L with both your hands and now take those and put them around your waist just above your hip bones. Now, what I want you to do is press out as hard as you can on your hands with your core and you can feel a lot of core activation. Most people think core activation is the front of your stomach, right? You're six back. What you need to do is create a cylinder around your back. So it's the front, it's the side and it's the back. So if you take your two fingers, point them, now put them just outside your belly button. Can you move your fingers by just moving your abs? 90% of people can sit do yes. Same exact thing. Now go to that same position just above what's called your ASIS. So your anterior superior, LX point right up that front of your hip bone right in the front. Can you now move? Great. 50% of people are not going to get any movement there. Take your thumb and go right above your PSIS. My what? PSIS posterior superior spine right now. Can you move? Most likely now. Sort of if I do a mini little back extension. Don't just with your core musketeer. Barely. Yeah. 90% of people can't. If you can't perform that contraction, you can't stabilize your spine. So only way to get stabilization your spine is then to go through hyper extension. And now that's a compression strategy you're putting on your spine. It's better than rounding your back like going forward, but overextension is not great either. So you want to be able to flex the musketeer in a cylindric fashion. So you have control. So if you go back to our very first things and with your hands open. And you put them right here. And if you're like, I can't get activation. If you pay attention to your thumb, right? Now just move your thumb. And now you see activation back there, right? Mm-hmm. Boom. Now if you can imagine turning that on just a little bit. And now notice how I can do this by the way at the same time I'm talking. If you have to go. We don't have control, right? So you have to be able to separate breath from brace. So now if I can put my position and Kelly started it as always at 20%. Give me 20% activation here. And now I can squat, I can hinge, I can jump. I don't need to be locked down to 100%. Scream to be able to brace my spine. That's going to be ineffective and wasteful. I want to be here. Well, the belt provides that proprioceptive feedback where I can put it on 20%. And it just is a reminder. If I don't press against the belt, the belt slides and falls down a little bit because it's not on super tight. If it's on so dang tight, it's doing the work and I forget. So we just want a little bit of feedback there. Same thing with your upper back. If you're having a difficult time activating those rhomboids of those lats. So I'm going to do a simple thing where they take their finger, put it right between your shoulder blades. And you just tell them things like, hey, squeeze my finger. Squeeze my finger. As you're doing your bent row or your pull down, you can touch the lat. You can do just visualization stuff. So just imagine like a 3D rendering of that muscle group and you're watching that muscle group contract. It's very powerful and very effective to do it. So touch, a visual, all this stuff can help get people to activate. Outside of simple awareness, typically eccentric overload is a very effective way for activation of a difficult to target muscle. So the lowering of the bar or the lowering of the weight. The movement of the weight away from the body is not necessarily with lowering because that kind of depends on what you're doing. Right, missbook, yeah. Things like a pull up. If I'm going to do a pull up and I have poor lat activation, I can still get the pull up muscle movement executed by contraction of the biceps and things like that. However, to make the movement simpler, I'm going to go all the way to the top. So imagine stepping out of box or something going all the way to that top of that pull up position. And starting from there, I want you to simply lower it under control. And so you're just simply breaking the movement down into smaller pieces that allow you to focus on the execution more. It's going to be great. Eastentrics are great for strength development, very good for hypertrophy, and allow you to focus on control. I'm willing to bet a huge percentage of you out there who've like, I've never had a sore lat. You know, I've done a lot of pull ups and things like that. If you do that Eastentric only, you'll probably wake up the next day going, oh gosh. I feel it there. And that's a sign even if you didn't feel it in the workout, but I got a little sore the next day. Keep down that path. And then eventually you'll be able to do a concentric, maybe take a break, maybe do an isometric, where you just hold that position, and eventually work that into a progression where you can do the concentric, Eastentric, and isometric portions, and get activation. So that may take you six weeks, may take you six months, but that's generally a pretty good strategy for learning how to activate a muscle group. And terrific suggestions. Is it true that Eastentric emphasized movements might require a little bit longer recovery, or they lead to more soreness than concentric movements? Yeah, they typically can, but they're also higher force output. So very good for strength development, but they're going to lead on average to more soreness. So more potential for interest cellular disruption that is going to be associated with pain. There's not as much people who like to explain muscle soreness as a result of micro trauma and micro tears in the muscle. That can happen, but that's not the norm. Most of the time it is things like disruption of calcium that's going to lead to excessive swelling, excessive pressure, and that's going to be then translated as extreme pain. So that's probably explaining more muscle soreness than actually micro trauma. Terrific. I was going to get to breathing later, but maybe just for now, if we can do a brief little foray into breathing, as it relates to weight training, is there a prescriptive for how to breathe during resistance training? Here I'm thinking of with weights, not necessarily body weight only movements, although I suppose it could be that applies 75% of the time to 75% of people. What I was taught, and I'm hoping you're going to tell me this was wrong, because then there might be more benefits that awaiting me, is that I should exhale on the effort and inhale on the lesser effort portion of an exercise. Is that true? Is there a better way to breathe? There is a better way to think about it. So number one, if you can breathe and brace, then this conversation goes away. So if you can maintain intramuscular, intramdominal pressure while breathing, then I don't really care when you breathe. Very challenging to do at very heavy weights. If we flag this on two areas of a paradigm, paradigm one over here, you're going to do a set of 30. And you're going to do front squats where a barbell is sitting on your throat. If you don't take a breath, this is going to end one way and one way only, you passing out. Clearly has to be some breathing strategy. The other end of the spectrum is, let's say you're going to do a vertical jump. You don't need any amount of breath there. It's never going to happen, right? The question is, what about in the middle? So I'm doing some sort of strength training there. Well, number one, make sure you're braced, and then you can get away with less need to worry about it. In general, a decent strategy is to maintain a breath hold during the lowering or eccentric or most dangerous part of the movement. And then you can exhale on the concentric portion. So if the bench presses our example, if you held in, braced, lowered it into control, and now started the concentric pushing away for it, and then you wanted to take an expiration. During the last half of the concentric portion, that's an okay strategy. If you're going to do a single rep, you don't need to worry about it. You can just avoid or omit breathing entirely. You're going to be just fine. If you're doing more than that, especially three to four to five to seven eight, you're going to have to have some breathing strategy. A very common one is probably every third breath. I'm going to do like, exhale on the third reset, re-breathe, something like that. You can need to breathe after every one. That's okay, but it's going to get wasteful because you have to take time in between reps of sitting there. If it's a squat, that's different versus a deadlift if you're resting at the bottom. So there is a little bit of game here. So in general, though, is that 75, 75 kind of really thrown out, you threw out. Breathe in through the lowering and exhale on the out. If you have to less reps, don't worry about more reps, then you need to come up with some sort of breathing strategy. It's about breathing in between sets and maybe even after the workout. This is something I think a lot of people overlook. Because it is the case that recovery has to do both with the specific activation and to muscles and the nervous system. But also the attacks on the nervous system can also take place between sets. If you're really geared up between sets and you go to adrenaline as high in between sets or close to it as you are during your sets, then you can imagine that the recovery would take longer. Or at least that you're not spending adrenaline in the most efficient way if there is such a thing. Yeah, fair. You're not going to see any athlete that I work with. Just breathe in between. Whether it's in between innings or in between rounds. Every single one of them is going to go back, sit in the stool, and they're going to immediately be into a breathing routine. A very intentional one. They're a little bit different from every athlete depending on the sport. We just hit our ball. We're moving to the next one. We're going to go in a breathing strategy. Everyone emits. It's a huge area of potential benefit and consequence if you're just ignoring it. In general, we want to do any sort of calming breath. We want to restore. It depends on if the depends on what combating or combating a little oxygen or high CO2. So that strategy is going to be a little bit different. But in general, that is a huge time opportunity to get better. In fact, people can go back and listen to some of your early episodes. You talked about what you have spoken about, I think, on this show. When neuroplasticity works. And if you're losing that opportunity, post-exercise, you're leaving gains on the table, if you will. So not only are you going to see every of the athletes that I work with mostly have a breathing strategy in competition, we're not going to just finish a workout high five drink water and walk out of the gym. There will be a down regulation strategy that is heavily involved with some sort of light control, as well as breath control. The individual prescription on that. There's a ton of variation with what you can do. The easiest thing is do something that calms you down. Most likely that's going to be moved towards as much nails or breathing as you can possibly do. And a really easy rule of thumb is a double exhale length relative to inhale. So if you need to take a four second inhale, double that time and breathe out for eight seconds. A box breathing is fine. So equal inhale, equal hold, equal exhale, equal hold. So four second inhale for second exhale, hold, etc. A triangle is fine too. There's a lot of ways you can get really complicated like what Brian McKenzie will do in Rob. Those guys have you can get all kinds of systems for inhale, exhale, control and can be optimized. But some strategy of calm. We're going to almost always put you on your back or close and then we're going to cover light. We can do some like we've done actually a number of musical interventions as well. But you can as just as simple as sit down a locker room if you have to. And just breathe for five minutes that alone is going to be productive. That's great. If you're breathing in the locker room for five minutes, I suggest closing your eyes or you get some funny looks. And if you'll still get funny looks, but you won't see people looking at you. Yeah, exactly. I love this. And I started doing this because you and Brian McKenzie informed me about this. And it completely changed the rate of recovery for me. I realized that I was leaving workouts, both endurance workouts and strength hypertrophy workouts. Feeling great, but looking at my phone, getting right into email and meetings, not concentrating on my breathing. And all I did was to introduce a on your recommendation a five minute down regulation. So exhale, emphasize breathing of a bunch of different varieties physiological size box breathing exhale, emphasize twice as long as the inhale component for five minutes. And I noticed two things. One, I recovered more quickly workout to workout. No question about it. Yeah, the numbers told me that. And the other is that I used to have this dip in energy that would occur three or four hours after a hard workout. And I always thought that had to do with the fact that I generally eat in the meal at some point post workout turns out it wasn't the meal at all. Yeah. It's that that adrenaline ramp up during the workouts. I wasn't clamping that at the end. And so I think eventually it's just crashed. And then three or four hours later, I'm having a hard time even reading what's on the screen of my computer thinking maybe it's the screen. Maybe it was what I ate for lunch turns out the down regulations allowed me to work through the afternoon with no issues whatsoever. Yeah, it's really been quite powerful. And so I'm grateful to you for that. And I think this is something that I think 98% of people are not doing. And it's only five minutes. You didn't have to do five. Give me three. If you really have to push it, give me three. And you can even do this. You can save time. You can do this in the shower. We have to. So you're you're done. You're finished. Drink of water, whatever has to be in your getting a shower, you're getting ready. Just giving three minutes in the shower. It's not ideal, but as little as that, it can pay huge dividends. You need some sort of internal signal that we're safe. Like throttle down here. We're going to move on. That has to happen. I could go on and on here, but I think we're making the same point kind of over again. It's big deal and do it. Yeah, and you're saving energy. I mean, the energy here is neural energy. I think fighters do this. Good fighters learn to do this between rounds. Yeah, sprinters learn to do this between events. I think humans should learn how to do this between any. You know, sort of interval type activity, including work. Social engagement. This is such a powerful tool. Do this for one minute after every important, whether it's an individual high volatile interaction, or if it's you just did a nice 45 minutes sprint to work and you're deep into it or whatever. Fine. Just give me one minute. Set your alarm. Just one minute and that also will pay dividends. I love it. And as I said, it's made to eat outsize different positive difference on my training, but also activities outside my training, which is for me, I'm not a professional athlete. I trained for health and because I enjoy it, but when a really hard workout starts in to fear with the ability to do the other things in life, that's not a good situation. So this is really terrific. There's a lot more in each of those categories of strength and hypertrophy, but you've given us a tremendous amount of valuable information there. Maybe now would be a good time to shift to endurance and of the four types of endurance. And maybe you could remind us what those are. What do you think are the two that most people are seeking or pursuing in terms of health and aesthetics? I'm going to realize that we probably have athletes out there as well, but I think when I think health and aesthetics, I think, okay, the ability to do sustained endurance 30 plus minutes of some ongoing activity. How does one maximize that work? What are the modifiable variables? And then maybe you could tell us what the other major category is that people ought to have in their kit. Okay. So starting off with exercise choice. One thing, as soon as we cross into the endurance world, and this is true for all four of those categories, exercise choice needs to be very concerned with eccentric landing. So you don't need to avoid it, but you need to recognize it relative or compare it against those other strength and speed ones. The volume is low on those ones. So if you have some eccentric absorption, it's okay. But as we sort of talked about five minutes ago, more eccentric means greater chance of muscle damage, so on us. So if you take something and magnify it across 30 minutes, or even five minutes, but of maximal exertion, you have a recipe for blowing up. You can imagine I haven't run in forever. And I've just listened to this human lab podcast and I'm, okay, I'm going to get into my zone to training, whatever, whatever. And I start jogging. I'm going to do, you know, I remember when I was I used to be able to do 25 and you just do a 25 minute jog. The amount of eccentric landing that just occurred on every single step because you're never with running, even slow running, you never have two feet on the ground at the same time. So one foot land, one foot land, your entire body mass plus gravity, under one leg at a time, repeated now hundreds of times. That eccentric landing is going to cause tremendous soreness. Your quads are going to go, you're probably going to get shin splints, which is what this isn't those are entirely caused by eccentric landing. And when the tissue is not ready to tolerate that, if you're not landing correctly, this is when knee pain happens back pain, shoulder neck pain, because of movement compensation. So anytime we start pressing to fatigue, let's be very concerned with there. So my initial recommendation is start with activities exercise choice wise that are mostly concentric based. So think about a cycle. So when you're riding on a bike, you're pushing the pedal, but you're never landing and absorbing it. So you could go out into a 45 minute bike ride and you're not going to get that sore because there's not a lot of eccentric load. Swimming, similar thing here, right? There's some eccentric when you're can. It's the water, but fairly minimal. It's mostly a push, push, push, push, push, no load. Rowing, similar thing, mostly concentric pushing a sled is fantastic going uphill, running or even walking hard uphill, all good because they're very minimal landing relative to like running downhill, which would be a very, very bad idea to start. When you, if you're first jumping into these things, progress your volume for endurance, very slowly, if it involves eccentric landing, a really bad strategy, we'd be to jump in and do, say, circuit training class that involves a bunch of box jumps. Right. This is not a good way to do your first four-way into conditioning. You're going to get incredibly sore because you're jumping in the landing. You're now looking at three to 10 X body weight in terms of absorption with a single land, even if you're just jumping. So be careful of that and any of those endurance areas of exercise choice. So what to pick? Pick the one that you are most technically proficient in because you're going to do it a lot. There's going to be a lot of repetitions. Whatever one you feel the most joy in, if that's growing, great, if that's pushing a sled, it doesn't really matter. You can do this actually with weights. This is our preferred way, by the way, with our athletes. So we might do a 30-minute circuit where we do a five-minute farmer's carry. With a pretty lightweight, so you're just going to carry some weights in your hand and you're just going to walk up and down the street for five minutes. You're going to set that down and then you're going to do, say, a three-minute plank. And then you're going to pick that up and you're going to do body weight squats, like slowly and just tempo. And you're going to do a handful of different exercises so the athletes don't get super bored. Or a very simple one, if a 30-minute workout, 10 minutes on a treadmill, 10 minutes on a bike, 10 minutes on a row. For those of you that are like, oh my god, I can't do 30 straight minutes running. Cool, break it up into three or four different exercises that are all fairly safe. So that's how I would do that long duration piece for exercise choice. And then in terms of heart rate during that period, I mean, how much tension should we pay to this? The kind of very broad prescriptive I've thrown out on this podcast a few times, based on my read of the literature. For most people that are oriented toward health, including people that are working on size and strength gains, hypergipane strength, of course, that getting 150 to 180 minutes of so-called zone to cardio, can just barely have a conversation. But if one were to push any harder, you wouldn't be able to do that kind of thing. It's just a generic recommendation that almost everybody should follow in order to just keep their cardiovascular system healthy. But I know there's a lot of nuance there. And some people would like to be able to run continuously for an hour at speed. Obviously not sprinting, but what are some of the finer, finer points on long distance endurance? So I often should one do it. Okay, frequency you could do it as daily. Even when strength doing strength and hypergipane strength. No question. Well, I think it's an important point for people to hear it, because a lot of people think that they are going to greatly diminish their strength and hypertrophy gains as it's often called by doing in zone to cardio. So zone to you have almost no ability to block your hypertrophy. Zone to truly within that category, if you're talking about conversational pace, there is very, in fact, there's strong reason to think that is not going to influence hypertrophy for the overwhelming majority of people. It might even help it by increasing blood flow to the various levels. Absolutely. Does it matter? Let's say someone's doing primarily strength and hypertrophy. Their primary goals are strength and hypertrophy, and then they're going to do, they're going to hit that 150 to 180 minutes in zone to cardio per week, assuming they're breaking that up into three or four sessions. Does it matter if they do it in the same workout before or after? Does that matter? I tend to do just by way of example for people. Certainly I'm just one example. I tend to do resistance training one day, then I'll do zone to cardio the next day I jog, because that's the thing I prefer. Then I'll do strength and hypertrophy training the next day, and then jog for my zone to cardio, and then I take one full day off a week. I've never actually done the zone to cardio on the same day, but were I to do it on the same day? Would it matter if I did it before or after my strength and hypertrophy training? Not really. You're going to be just fine. The interference effect is what this is called. This is all the way back to 1980 about Hickman's stuff. He was actually working in a lab with John Halazi, one of the fathers of exercise biochemistry. The story goes that Hickman came in and he was a strength training guy. Halazi and almost all those initial exercise physiologists were conditioning folks. It's almost always swimmers and runners. That's why a bulk of the exercise physiology historically is shaped in that direction, and it's one of those scientists we're interested in. Hickman was there in the lab and how much of this is myth or not, over the nose, but so the story goes. There's this sort of chipping back and forth, and you know how from a PI to a postdoc, and that rousing works a little bit. Eventually he's like, you got to start running with us, and he's like, you got to start lifting with me, and kind of goes back and forth. You know who wins that equation. It's not the postdoc. The PI gets in and says, Hickman is okay fine. So he starts running with Halazi and eventually starts to realize I'm getting weak. I'm losing strength and I just can't. I think it was his bench press specifically was going down or maybe a squat. I can't remember who knows if it's even real, but point is. So he's going along and so eventually that starts to create a little bit of animosity. And it's like, actually, I don't think this is good for me. And then blah blah blah, and so they did what any good scientists would do and said, well, let's find out. So he run a really famous experiment where he took a group, three groups. One group did an endurance piece, right, the steady state cardio. One group did a strength training piece. And then the third group did both of those workouts combined, not like a reduction. So both volumes stacked on top of each other. And the results are fairly predictable in terms of the endurance group only had the greatest increases in VO2 max on endurance markers. The strength training group had the greatest increases in muscle hypertrophy. But where the interesting part was where this whole field started was the combined groups. So this is concurrent training is what it's generally called. So you're doing concurrent things. And typically that means hypertrophy and strength stacked on top of some steady state endurance. In the same work. Same same work out. Same two hour block. Or same like week. It doesn't really make it can be kind of all these. Well, the concurrent group saw the same improvements in VO2 max as the endurance group. And he's like, well, okay. So the strength training did not compromise the endurance adaptations. However, they saw much lower increases in strength than hypertrophy. And so it was the conclusion was the addition of endurance work. Compromised muscle growth and strength development. However, the addition of strength training to your endurance work will not compromise your endurance gains. Now that second piece has been shown countless more times. So if you're an endurance athlete, adding strength training is almost always going to be massively beneficial. Very little chance of judgment. Or is it why every endurance athlete is going to have some sort of strength and power component of their training. The controversy though came in the interference effect. So how much endurance training really blocks muscular development? And for years, myself included was we preached hard. You know, don't do these two things at the same time. My friend, my colleague Kevin Mirac has a really nice review article, Jimmy Bagley. Those two guys put this thing out. You can go read that where they cover all these things. And they've got some nice figures in there. But the general answer here is interference effect is sort of real. But it's probably greatly overblown. It matters. So are you talking about a 20 minute jog at conversation pace? That's probably doing very little with the assumption that are you doing an eccentric based exercise like running? Well, then you're going to have more of interference effect than cycling. That makes a ton of sense if you think about it, right? What's your total energy intake? If you're eating sufficient calories, you can still be in an animal X-Tate. If the addition of extra energy expenditure, it's all it really is, Mark, the cardio, put you in a negative energy state. It's going to become very difficult to go through anibalism. So those things matter. If you're talking about doing like running a few laps around the track as a warm-up, like that's not interference effect. What we're really talking about is a big volume performance consistently. Now, after Hickman came out with this paper in 1980, people followed it up in the 90s and 2000s with mechanism. And we started to look and see, we started to see, hey, there's this cell-signal-y pathway that goes down to called M-tore. And that's what leads to muscle growth. And then on the other side of that equation, there's a thing called AMPK, which is more associated with mitochondrial biogenesis and endurance. And there's this little molecule in between at the time most people would point to TSC2. Well, turns out AMPK activation is fine. If you activate M-tore, there's no bearing on AMPK, but if you activate AMPK, it's going to activate TSC2, which inhibits M-tore. And so it was like, we had practical outcome. I eat Hickman. You're going to get weaker. Now we had mechanism. So that story became very, very strong that this interference effect. And this is how science should work, right? When you see mechanism match up with practical human outcome. It's a strong thing. It was still wrong though. It just took more science, right? And this is why we always have to give science a bit of time. And you have to be willing to follow, right? And again, even me in the field, who has a practitioner background and science, I felt very strongly, this is a big problem. It just didn't turn out to be the case. And enough studies came out where I'm like, OK, it's probably not that big a deal. Unless the movement is heavily eccentric based, the volume is very high. You're trying to maximize muscle growth and energy is not controlled. If that's not all the case, the interference effect is probably not something most people should worry about. When you compare that against the well-roundedness that you need for total physiological health, probably not a big deal. Very reassuring for me to hear because I do enjoy lifting weights and I really enjoy running. And I love running outside. I believe I used to experience the interference effect when I used to do a very long run on Sundays. I would just go out for two hours or something like that. I don't know that I ate enough or who knows. I always feel like I eat enough or more. I love to eat. But that long Sunday run always made it hard for me to make progressive games. I want to make course games and strength and hypertrophy in the gym. Whereas when I cut that to 30 minutes, three or four times a week, I don't see any interference effect at all. And I haven't trained specifically for endurance in a very long time. So I don't have it to experience the non-interference effect, which as you said before, most, if not all endurance athletes probably are or at least should be doing some sort of strength work. Just to keep the undercarriage strong, as I think the country is. So what are some protocols that people could explore for continuous endurance training? I mean, I've thrown out this 150 to 180-minute zone to cardio, but that's really the kind of kindergarten of endurance. And there I'm probably being generous. It's probably the nursery school of endurance that everyone should do. What sorts of other protocols? I realize that can be very goal-directed. But is it unreasonable, for instance, for somebody to do four hours of continuous endurance training with intervals in there as well to get it all around heart health and the ability to go long distances? Yeah, I'll answer this too. It's the very first one. The tackle, the long duration endurance is however, for you to go. You ask really about heart rate zones. To me, that's almost totally irrelevant. It doesn't matter, right? If you're moving, you're moving. That's the functional piece here. If you want to push it and go at a non-conversational pace, that has tremendous health benefits. If you want to do it a little bit slower, fine. If you're at the pace where you can have a conversation, to me, I don't even count that as exercise. That's not a pejorative, by the way. That is just general physical movement. And it is extraordinarily clear. You need a lot of that. You need a lot more of that than we get. You can do this in a couple of efficient ways, just taking your phone calls moving. If you've got a 30-minute call every day, or most days of the week, and you can do that while moving, you've checked not that whole box, but a pretty good chunk of it. And that could even be done inside. 100% pacing back and forth. I'm a big pacer. Yeah, me too. You probably saw me. I'm going to walk up and down all over the place. Most of the time when I'm in my office working, I come. I'm shadow boxing. I come to an air squat. Not even intentionally. I'm just like... Do you have one of those treadmills under the desk? I don't, but every lab I ever came through somebody did. We did an episode on Workspace Optimization. The data on those treadmills are pretty interesting. They definitely increase alertness, which for obvious reasons, even a little bit of movement is going to generate a little bit of adrenaline. So pacing around, moving, taking calls, moving, getting walks when you can, and then in terms of building endurance, let's say somebody wants to get into better shape. They already... May or may not already have some size and strength that they're happy with, and they just want to improve their health. So I can... So I can... What does that 150, 180-mit thing tick over into a different protocol? Yeah. I think the way that I can outline a weekly schedule, just as a conceptual model here. That long-duration stuff is not even counting, as I mentioned, right? It's just a... This is what you need to do as a human. We haven't improved. If you're extremely unfit, you may see some changes in cardiovascular health. For the most part, this is just knocking out the general physical practice you need to be on your functioning. So whatever that time domain is, I don't really care. It's not a huge concern of mine. What I think you need to hit are these nodes. You need to do something once a week that gets you to a maximum heart rate. Now, I don't have to literally mean max, but close. This means really sucking for air. Really? Like, as high as you can possibly get, you can wear a heart rate monitor if you want. But maximum heart rate, the rough equation we say is 220-year-age. So if you're 40 years old, your maximum heart rate is probably about 180 beats per minute. Now I can tell you flat out right now. My max heart rate is close to 210, which means I'm 10 years old. So take that number with a grain of salt. I have had a bunch of professional athletes who are in their 20s and their max heart rate is 175. And they are way better shaped than I am. So maximum heart rate is not a good proxy for physical fitness. It's a rough number. An easy way to do it is if you have a heart rate monitor or anything like that, do the hardest workout you can possibly do. See what the highest number you get as soon as that's close. If you want to just start at 220-year-age, that's fine too. Do something though where you're like, yep, this is death. This is really, really challenging. How long? However long that takes you. That can be a 30-second go on an aerodine or aerosol bike. That could be a do one of those things where you kind of like sprint, run as hard as you can during the straightaway on a track and then walk the corners. Kind of an old classic back when I knew an Iber kid's interval training. They don't do that anymore. I guess I don't know how I would have talked about it. In PE class, we had to change. If you didn't bring running shoes, you had to do it barefoot. Oh, I love it. I love your teacher. Yeah, it wasn't a football, baseball teams weren't that good, but anything like running across country just because of where I grew up. With brutal coaches. Yeah, they'd make all kids do these runs. Yeah. So it can be in the 30-probably seconds at a minimum. It's hard to get you to a true heart rate max in shorter than 30 seconds. You can get the total suck in under 20 seconds, but getting to a true heart rate max is probably going to take more than 30 seconds. So it doesn't really matter what you want to do. It can be again, a sprint up hill. It could be what you're talking. It could be burpees to death. You know, like whatever you want to do just- Well, those have an eccentric component, right? Yeah, they do. Yeah. No question about it. But if you did- No, to actual death, by the way. If you just did, I'm going to do as many burpees as I can for 90 seconds. They probably won't take you much longer than that to get to close to- And his acts are workout. It could be. So once a week, get to max heart rate. Touch it. I love it. Touch it. It's not the best, but it'll work. And what are the specific benefits that that provides? Okay. So, earlier in our chat, we outlined the real specificity, specific adaptation to a post-man. If you're never getting to that high of a pace, you're never- It would be like trying to get stronger, but only going to 60%. So every cardiovascular adaptation that occurs with cardiovascular training is just simply going to get to the top or end by doing this. So if you just start at the heart itself, stroke volume increase. So this is a amount of blood that's kicked out per contraction, cardiac output, resting heart rate. If you go to the endothelial function that you're talking about, nitric oxide release, endothelial health in general, capillary, mitochondria all the way down. Like you just walk through the whole system, pulmonary exchange to the lungs. All of those are going to benefit by being challenged to their maximum. You also teach you where your vomit reflexes. Yeah. Right? Let's hope no. Stress is what causes adaptation, right? So if you push your, okay, here's the difference. If you did 25 minutes of steady state, you're not challenging the same thing as what we just talked about. The way that I explain this is if you understand the point, the point of physiological failure, then you understand the place of adaptation. That's it. So if you and I both go run on a, we did a, we did a VO2 max test. So a classic VO2 max test is going to take eight to 12 minutes and it's going to look something like this. We're going to get in a treadmill and we're going to run and every minute, I'm going to just slightly increase that treadmill, either the speed of the grade, most of the time it's the speed, right? So we get to a high grade, say 10 percent grade or something and then we go five hours per hour, 5.2, 5.4, 5.5, and we just go until you can't go any longer. Now let's say you and I did that and we had the same exact time frame. So we both went eight minutes. The time that you last is not the thing that we care about, right? It's the volume of oxygen that you breathe out is what determines it. So let's say we went with the same time domain and we had the same VO2 max. Let's say they were both 50 milliliters per kilogram per minute, which is like a okay number, but that's nothing to be extremely proud about. Just because we have the same number does not mean we have the same point of physiological failure. And this matters because it's going to answer the what do I do about it then question, right? So if you got off and I started asking you serious questions and you're like, and I basically said, why'd you quit? You know, why did you jump off the treadmill? Why'd you stop? And you were like, my chest, like I couldn't catch my breath. I thought my heart was going to explode. Okay, great. If you ask me and I said, my legs were on fire. Like I was breathing hard, but I couldn't take another step. This is a very rough indicator of different places of physiological. Disruption. Now, what I've seen a lot with my professional athletes, especially like fighters, they're going to generally fail their legs because they don't often do a lot of strength training in their legs. They don't do a lot of legwork. They're fighting on their back literally a lot or on top or on their knees. So there are legs tend to give out before there. Someone who feels in the cardiovascular system, like say you did a lot of leg training, typically I can endurance athlete, who's that's not going to be their issue. It's just going to be they're going to reach a heart rate and ventilation threshold. It's like a no longer handle. If I put you on the exact same training protocols, it's not going to be as effective because you're going to always fail at your legs and they're going to always fail at their cardiovascular system. I need to flip that. You need to put you in a position to where you can reach a true heart rate or ventilation challenge while your legs are still hanging in there or the opposite. So the training protocol is based on that point of failure. The adaptation is in the same thing. So if you are failing because of your legs, then you might see a greater increase in capitalization in your legs. Relative to somebody else who's failing in their cardiovascular system, they may see a greater change in something on that side of the equation. So that it matters how you're failing at all times. What I love about this is that it sounds like it's like a thermometer for where one is weak and needs work, but also provides a stimulus to improve the very thing that you need. That's the trick. That's the trick. So to just get real brass tax about it, it would be once a week, 90 seconds near maximum heart rate, could I do more? Could I do five or six of those 90 second bouts? No question. As long as you touch that max heart rate, I'm good. Ideal world probably four to eight in that single session. Ideal. If that takes you 20 seconds or 90 seconds, it's fine. If you want to do 30 on 30 off, you want to do 20 on 40 off, 40 on 20 off, those numbers don't matter. Is there an interference effect of this on the other sorts of training that we've talked about? It actually tends to be complimentary. The evidence available suggests that this high interval stuff is more likely to be complimentary to hypertrophy training, probably because of lactate and some other cool things, which are very beneficial molecules that people don't understand. They think it's bad. It's actually a hugely beneficial thing. It can be interference, it can provide interference. If calories are not accounted for, if rest is not accounted for, and other things, but in general, it's probably okay. I wouldn't add it to your equation if you don't need it for maximizing hypertrophy, but for the person who wants to just get well-rounded physiology, I wouldn't hesitate to do these even in the same session or different sessions. Terrific. If that's done once a week and the 150 to 180 minutes or so of zone two cardio is done the rest of the week, the person is doing their strength and hypertrophy training we would hope. What other sorts of endurance practices could one incorporate? You mentioned muscular endurance. The ability would like a wall sit or the ability to do a plank. Is that something that is that useful for anything? Yes. Is that doing planks and wall sit? No, no, it's extraordinarily useful. Let's hold on muscular endurance. I want to finish one more thing on this side. If we're building this week of endurance. Once a week hit that number, if you can do repeated bouts, we talked four to eight, that's fantastic. If you can't manage the mental energy every week, do it every other week. It's still very good, right? I get it. I'm a working person too. Sometimes you're just like, I cannot. Those workouts feel incredible afterwards, but man, they are daunting. If you love this stuff, you could do it four times a week. If you hate it though, it's not realistic to think you're going to be able to knock this out. You're going to end up doing 70, 80%, which is not going to get you the benefits. Just don't do it. You really have to hit that. You've got to get up there. Close. Have someone chase, I always say, when doing this kind of work in my mind, I'm thinking that I'm basically being chased by somebody with a syringe full of poison. While there are other ways out of the situation, for the benefit of what we're talking about, what I'm referring to is to just run. My motivation is typically, if you just get this done, we're done in a couple of minutes. Just get it done. Don't go here if you're not going to do it. You show up, check in, and it's over really quickly. Breathing down regulation after we're done. 100%. You have to. It's an easy, huge key. If you absolutely can't do it, do it every other week. That's twice a month. Give me twice a month. It can be done on the road. It can be done at 20 minutes. Do it really good through a warm-up. Don't just jump into those by the way right away. It's not going to be as beneficial. Really nice, good sweat broke. I have really good warm-up and then give me four minutes of hard work and we're done. Get out of there. If you want to use a bath or hot thermal stress to aid in that warm-up process, find getting the sauna and getting a hot bath. Get really hot. Get up there, warm-up, knock it out. Whole thing is 20 minutes plus five minutes breathing. I'm going to start doing this. It's so bad. You got a bike right there. Yeah, I've got all sorts of every room in this studio. It has a different piece of equipment it seems. I want that once a week, realistically every week if I have to. I want that physical activity piece. Call it whatever you want, long duration thing. Ideally you'll do as much of that through your nose only. You're not going to be able to do the interval stuff at nose only. Don't even try. If you can go that whole 30 minute time or 20 or 40 minutes, whatever it's going to be, that's actually a good way to regulate intensity. So it goes hard as you can while still being able to breathe through your nose only. If you have to open up your mouth a little bit, fine, but try to stay there. What you'll see is very quickly, you'll be able to increase your workout put while just breathing through your nose, which has a bunch of other benefits. The other piece I want is this middle ground, which is can you sustain hard work for eight to 12, maybe is little four minutes. I'll give you four to 12 minutes. This doesn't have to be quite as high as the first one. You don't have to get to a heart and max, but can you get somewhere in the 80% range and can you hold that for four minutes? Maybe give me two minutes, two minutes to rest and do that twice, something like that. Ideal situation is what a runner would do is like what we'll call mile repeats because they're running four or five minute miles. Whatever time it takes them to finish, they're going to rest that. So it's a one to one worked rest ratio. So a five minute mile, rest five minutes and go again. That's probably pretty unrealistic for a lot of folks. Well, the five minute part is unrealistic for most folks. For me, it would be eight minutes, eight minutes. It's fine. Probably something like that. Well, in your particular case, just do the 800 meter. So do 800 meters. Do something that takes two to six minutes to work. It is a lower intensity than the max stuff, but it's a much higher workload. That is probably going to give you, you might even argue, the most cardiovascular benefit because it is sustained work output. That's very critical. The downside of kind of like that conversational pace, it's physical activity, it's movement, it's blood flow, it's lymphatic drainage, it's not very cardiovascular challenging that. You're just not going to get an optimal health from just walking actively. So two to six minutes of hard work, of hard work with an equivalent amount of rest in between and then repeat how many times? Once if you have to, if it needs to be one rep, if it needs to be a six minute thing and then down regularly breathe twice, if you can do that six times, eight times, whatever you can really do. You can just take that as long as the training session as you want or short. Exercise choice can be whatever you want. So again, you can do sled pushes or it could be a kettlebell circuit or any combination of things where you're just, you're working and you're not giving yourself a break. You have got to be able to hold on at a very high waste product production level as well as a high demand for energy and then bring it down. Breathing during this two to six minutes of hard output is mainly through the nose or combination nose and mouth. Or is that getting too technical? Well, it's probably like I like it, but you tell me if it's too technical. You're going to try to maintain nasalone as much as you can, but you're going to lose it at some point. You can go through their Brian and Rob's gear system and learn more and then you can kind of see what gear to be in. If you have to go nose in, mouth out or something like that, but I don't really care too much honestly in that range, I'm getting most of my nasal only stuff at night and training and everything. So if you have to open up the throttle there to get the work done, that's okay. Oh, then we'll actually go to your answer your question, which is muskinar endurance. Let's go back to that piece. Muskinar endurance is incredibly important for general maintenance of joint health. In other words, you have got form follows function, right? It's a very classic science-y physiology saying meaning you've got a couple of different, there's a bunch, but to make it easy, two different types of muscle fibers, fast twitch and slow twitch, fast twitch fibers tend to be, but they're not always bigger. They contract with a higher velocity. That's why they are called fast twitch, but they tend to be more glycolytic and thus fatigable. Slow twitch are tend to be smaller, they're not always. They are more packed with mitochondria that were generally better at burning fat as fuel but contract lower velocity. Well we have these two types so that we can regulate function more. You have some muscle groups that we're going to, oh, sorry, let me go back up a quick second. Each individual muscle in a human body has a combination of some amount of fast and some amount of slow. That percentage of fast versus slow differs from muscle to muscle. So it also differs from person to person. Easy example is your calf muscle. There's three, but there's two primary muscles in your calf. One's called the soleus one's a gastroc. The gastroc is the one where if you take your toe and point it towards your face and then flex, that's the one that pops out on the medial side, the inside. The soleus is what we call an anti-gravity muscle and it is generally about 80% to even 90% slow twitch. That's because it's supposed to be contracted lightly all time, supposed to be on permanently. It's meant to keep, we call it anti-gravity because it's meant to keep you erect up and moving. So the spinal erector is supposed to do this various muscles for postural or are generally slow twitch muscles. So we're supposed to be on all times, not produce fast, not produce force, but don't get tired. The gastroc is the opposite. It's not activated very often, but when it's activated, it's meant for extreme propulsion. This gives us the ability to reach up and scratch our eyeball and also punch somebody. We have to be able to regulate force output, which is going back to henomen, right? Moving what we use and what we don't use while also not wasting energy, which is the downside of activating a big threshold motor neuron is it requires a ton of energy. Some more efficient motor energy, but the total amount is really, really high. So muscular endurance is going to help those slow twitch muscle fibers and slow twitch predominant muscles maintain their working job. So if you lose your muscular endurance ability in your spinal erector or your calf, you're going to start slumping into bad positions. You're going to be getting, putting joints in a movement pattern that they're not going to be the most happy with. So it's more than about then being able to just maintain a two minute wall squat. It's about maintaining joint integrity and allowing that musculature to not fatigue when you ask it to do heavy and fast. So what I mean by that is you've got a whole combination of muscles in your shoulder. And we will generally call these like the rotator cuff muscles. So let's imagine those slow twitch postural muscles get fatigued and they start to lose contractile tension. And then you go to do something heavy or fast or an emergency situation. Those are already prefatigued. You're going to rely more upon the faster muscle fibers, which are there less for postural integrity. You're likely to get out of position. And this is a whole recipe of like, God, why is my shoulder just hurting? Got my back. It's very often a case of the slow twitch fibers, the slow chit muscle groups losing muscular endurance. So you need to build that back up so that they can control and hold the joint in the position so the faster it's virus is because they contract with force. I'm hoping that what I'm going to say next meets what you said accurately. My experience is that getting injured, lifting weights or even doing housework or yardwork almost always happens when I'm not paying attention fatigued, that's kind of obvious, but also getting in position to initiate a movement, setting down a weight or lifting weights off the rack or picking up dumbbells. That's almost always when I seem to activate this lower back thing that happens every six or eight months. And what you're saying, if I understand correctly, is that this muscular endurance from wall sits or planks or things of that sort, maybe you could give us a few other examples of these can help us because they actually prepare the system to do what we normally think of as the more intense work. So it's really that it sounds like it's really the architecture of the body that includes nerves and muscles and everything else, of course, that lets the limbs and other kind of action end of the body do its best work. Yeah, let it express its own power and force. We actually landed on one of my final laws of strength conditioning, which is similar to what I said earlier, right? So I said, exercises do not determine adaptations, application determines adaptation. So it sounds similar, but it's quite different. There are no good or bad exercises. There's only good or bad application. Here's a great example of that, right? So you do not get hurt deadlifting because dead lifts are dangerous. You only get hurt deadlifting because you either got in bad position. You either got in bad position because you either started in bad position, which is one of the things you just said, or you ended up in bad position. You did too much volume. You did too much intensity or you did too much complexity. Those last three things all hurt you because they result in the first one, which is out of position. Or another way to think about this is if it's not a visible change in position is stress got put into a part of the system that should not absorb that much stress. So you did too much of it. You did it too heavy. You got fatigue, so you broke position. You got too heavy, so you broke position. You made that exercise too complex. You put too many moving parts in it. You put too many joints in it, and you got out of position. You did that too many times over time. Now we've led for either an acute injury, bam, back pops and you fall on the floor, or it is like, man, this thing is hurting over time. All these are results of the same thing. So you cannot ever blame the exercise for causing the problem. It's always either the user or the coach. You programmed way too much here, and I can't handle that position or you yourself went into it too much. So if you're getting these little tweaks and problems going on, you've made an error in one of those things. So simply back off. Use the complexity. Give yourself more stability, less moving parts. Do less volume. Do less intensity. In fact, if you look at the people from the physical therapy world in terms of the pain, literature, it's very clear that just stopping a movement is very rarely going to work. What you want to do is back off all the way down to just below that threshold of, that's what aggravates it. And you want to train right there. That's going to allow you to do two things. Number one, tissue tolerance, and then number two, desensitization. A lot of pain stuff, and you can probably speak a lot about this, is especially things like low back pain, is there's not necessarily often much damage there. It's a lot of hypersensitization of just pain signal, pain signal. Omitting the movement entirely does not get that signal to go away. You need to train just below that signal and desensitize it. So you want to make sure that the muscular endurance allows you, you're just putting volume right below where you start to get a tweak. And it is beautifully effective for that. I've experienced this right side lower back pain for years, sometimes shooting down the two things that really helped were doing anterior tip work. So hats off to knees over toes, sky, bandpatrick, who has created a lot of popularity around tip work. Turns out joints, full range of motion, you're in a better spot. Yeah, something about stabilizing the stuff from the knee down helped my back. And then also some neck work and friends of mine are always teasing me that my gym is filled with the most bizarre equipment. It doesn't look like any other gym. A lot of it is just designed to keep me healthy and still training. But I love this idea of getting right at the below the threshold of pain activation and not simply going into complete non-action or just taking complete rest because that actually can be detrimental. I'd love to talk about a few items that support training of all kinds and where there's a lot of confusion and indeed misconception and mystery. You just get your take on these and I just want to acknowledge at the outset that for some of these there's a lot of science, for some of them there's less science, but there certainly is a lot of experience in your camp. And those categories are cold, heat and hydration because obviously whether or not you're a runner or whether or not you're strength training, if you're a human being, you need to hydrate. But in terms of work output and physical work output, maybe you can cognitive work output, maybe tackle hydration first. There is what I call and what I think is now come to be known as the Galpin equation, which you really do deserve credit for because I think that people realize that there are range of solutions out there, but there is a desperate need for straightforward solutions that work for 75% of people, 75% of the time. So hydration is key. Maybe you could underscore just how key it is for us. And then what is the Galpin equation as I call it and I think others are now referring to it. Yeah. Okay. Benefits of hydration, slash consequences of mishydration. So whether it's dehydration or overload, physiology has aromatic curves. Right? Not typically we think about this in terms of toxicology. So what this means is at some point giving you a dose of something up testosterone is a very easy example. If you are clinically deficient or low in testosterone and I give you a little bit and it brings you back to a normal range, you generally see an improvement in health and functionality, taking you though from normal to super high doesn't always necessarily provide additional benefit. In fact, if you continue to go, it's going to provide detriment. Right? So everything has its curve and then some things are hormatic stressors, which means like a small short fast insult is actually beneficial because then you come back bigger, faster, stronger. That's how an adaptation works. Basic hormises. Okay. Hydration is the same way. So at the end of the curve here, if you are under hydrated, well, I'll know you could die, right? You have to have things. In fact, water is the only thing that is ubiquitous across biologies in terms of every living thing has to have it. There's no other vitamin, mineral nutrient that is required among all living things with the exception of water. So that should give you a pretty good indication of it's important day, right? Like you got to have this thing. One here, the bottom, if you're dehydrated and I give you more, it's beneficial effects. However, if you're up the top already and I continue to give you more water past that, now we run into actual problems. And we can give what's called hyponotremia, which is more common than people realize. Nitremia being actually not referring to the water, but the sodium concentration being too low. And you've probably talked about that a length of why that's an issue. If sodium potassium balances inside, outside of cell come off, you heart stops, right? So contraction ends and all these things. So you don't want to be over or under hydrated. So understanding this rough equation I sort of loosely calculated one day is helpful for that. I think the most context is talking about how much water to drink throughout the day and then how much water to drink during exercise. So the very easy answer is half your body weight and ounces per day is a very loose guideline for total amount of fluid consumption. So if you weigh 200 pounds and for 100 ounces of water, it's like a very easy number. If you hit that, you're probably, I'd say 90% of you are good 90% of the time alone. If you then go to exercise, you need to then account for that fluid loss with exercise. And in general, you want to consume 125% to 150% of the amount of weight you lost in fluid. In other words, if you worked out and you were 200 pounds naked and you ended your workout and then you dried off and you weighed yourself again and now you're 198 pounds. You lost two pounds of water. That's 32 ounces. You want to drink back about 125% of that. So instead of drinking 32 ounces, I want you to drink 42, 45, like something like this. Because one of the reasons why is unless you're drinking something that is isotonic, meaning the same exact concentration in your blood that you're in your fluid, you're just going to go closer to that hypnotrimia. You're going to get a bunch of better or reflector responses and you're going to actually think you have too much fluid and you're going to urinate it out. Which is not weighing myself before and after workouts. Is there a shorthand version of this that after training for an hour, I should drink at least revounces? Yeah, that does. Assuming it's at kind of taller, I'm not sweating super heavily. Yeah. In that particular case, you could probably go something like if everyone in the world did, I don't know, 12 to 20 ounces, that's probably pretty decent. And they're probably doing that. Yeah. And what about electrolytes, a consuming salt potassium and maybe that thing only works though if you're coming in at optimization. And this is the problem. This is why you have to flag this starting with a good, total daily amount of water. Because if you're coming in and you're like, oh, I drank two or three glasses of water a day, then you might need to drink 50 or 60 ounces post workout because you're way behind. So that like, oh, 12 ounces or so works if you're already generally very well hydrated. And if people are drinking four to six glasses of water a day, but they're also drinking a lot of caffeine in any form, then they're going to be excreting more water in most cases, right? Well, because caffeine is a diuretic. Okay. It kind of is, but it kind of isn't either. It's not the diuretic that we used to think about it as. It is still fluid consumption. So it's only a diuretic. If it causes you to excrete more fluid than it actually was being intact. So if caffeine intake is in a normal range, I don't have to worry about the diuretic effects. If someone is drinking 12 cups of coffee a day, or they're taking caffeine pills or something, now the excretion is going to outkick the coverage. So now we're now problems, right? Because there's no fluid consumption with a caffeine pill. So in general, things like tea, consumption, like I'm not super worried about those things. You can count those torsure total fluid intake if you want. So if you're like, I drank 60 ounces of water plus 20 ounces of coffee and then you know this, like you're going to add that all up and you're going to be totally okay. So natural, you also have problems with synthetic forms of caffeine versus natural forms of caffeine. Natural forms are pretty okay. It's a good idea to get coffee tea, etc. Yeah. Natural form is where it gets tricky. Always, like ever, always, right? So general, just eat real food and things. You're going to be just fine. The last piece to consider is your diet quality matters because the fluid content in your food can vary wildly. So something like a bagel might be, you know, 5 to 10% water or something like a watermelon is 98%, 95%. Eating in a huge range, even meat is very high percentage of fluid intake. Like it's really high even after you cook it. There's still a lot of fluid in there. So if you're eating a whole food, mostly whole food based diet, your endogenous hydration is actually pretty high already just from your food. If you're eating a very highly processed dehydrated, oversalted diet, you're way low on hydration just in your food. So you have to factor all these things in. In fact, one of the things that happens to us constantly with folks that go from a highly processed low quality diet to a high quality one is they're just peeing on stop. Like, what the hell is going on? I'm like, well, you actually have brought in 60 additional ounces of water in your diet relative to what you used to have. And you've gone from 10 grams of sodium there to four to two, sometimes one, sometimes it gets very low because you're not like salt. Are you salt in your food? No. Okay. Well, we don't have sodium intake then. We're weighed down. So everything that we're considering is based on that. So let's assume someone's eating a pretty well balanced diet. They're drinking 60 ounces of water and maybe some caffeine, coffee and tea, things like that. We don't exactly know the optimal amount of sodium one should intake. It is very clear. High sodium concentrations are still associated with a lot of negative health outcomes, especially in combination with port physical activity and combination with low food quality and all their comorbidities. That's a very bad thing. You need to be very careful about those things. If everything else is okay, we're okay playing with a little bit of higher salt. In fact, you're probably going to feel better. You're going to feel generally pretty good. It needs to be very clear. If you are overweight, highly stressed and you don't have a lot of these things ticked off and you have known comorbidities, you really need to pay attention to salt intake. It can be very nasty. So that being said, what we're generally going to look at, folks, is are you at least can we categorize you as a low sodium or high sodium sweater? If so, there's a whole list of electrolytes you can look that are going to have something like 200 to 400 milligrams per serving. There's a whole list of these things. If you're a low sodium sweater, I'm probably going to send you after one of those. If you're a high sodium sweater, there's a lot of electrolytes supplements that are closer to 600 or even a whole gram per single serving size. So you want to play with that. I very, very, very, very, very, very, very, very, very, very, very, very low sodium or high sodium sweater. We actually have an episode on salt. We put out that, or is coming out soon, if hasn't come out already, which is, when you look at the hazard ratios, your salt intake, basically your probability of really bad things happen to you, goes way up as you get towards a lot of sodium intake, 10, 12 grams per day. And this is translate to teaspoons of salt, et cetera, but also very low sodium intake is a problem. No question about that. It's not a perfect U shape. It's kind of a J-shaped curve or a hockey stick shape, more or less. But how would I know if I'm a low sodium or a high sodium sweater? Yeah. So you can get some. Would I just kind of lick my sweat or have someone else do it? Well, you can. Yeah. Find a super friend who'll lick your sweat for you. That's the same with how. No, no willing volunteers that I'm aware of. But would I be able to tell? Yeah. You can get sweat testing done. Actually, you have a number of options. The original one that most of us use in the background for many years was called Babylon. They'll send you out a little patch. You can wear that and send it in the lab and the little measure it directly in the lab and send it back is 150 bucks or like. Did they be you into low, medium and high? So they're going to do that, but they're going to give you very, they're going to tell you exactly the milligrams. And then they're going to actually tell you like what products and stuff and that they're exactly matched. Do you do this with that with professional athletes? We have many times. Yeah. Interesting. You can do a more consumer grade version, Gay raid, has a patch for 25 bucks. You can get two of them. You can put that patch on your left forearm and download the Gay raid app and you can do a workout, measure it right there and click it over and they'll tell you exactly not only higher low, but again, they'll tell you the milligrams of sodium that are in your sweat and you can figure out again, kind of high medium or long. Interesting. They do much better on a slightly higher sodium intake. Most do. But in my carbohydrate, I do eat carbohydrates on one of those that it is pretty moderate but I try and eat clean food. So I notice and I tend to be slightly low blood pressure. So again, to reiterate the warning there that if somebody is a prehypertension or has hypertension or obese, you really do need to be careful with your sodium intake. But many people seem to find that they feel better when they increase their sodium intake and they're still in that healthy portion of the hazard ratio. Most of the athletes, I would say in general, we're going to go higher in salt. When they come, we're going to run their stuff and we're going to add salt almost always. And very few times have I gone out, we need to cut this back. One of the exception of the ones that come in that eat like 14 year olds. And I'm like, okay, you're at 15 milligrams or 15 grams a day because you're eating nothing but garbage. So we're going to come down, you're going to feel way better and all this bloating and everything else that's going to happen. Go down. You can do that. They're actually more, they're biosensors that are coming out that are not available yet but they're coming very soon in this space. They're going to be able to give you real time metrics on salt. So you can pay attention to those. I haven't seen one in use one personally so I don't want to espouse about how good or bad it is but I know that those are coming from a handful of companies. An easy way to do is just look at where it happened or where some sort of headband or something and do your workout. Take it off. If you see a just huge white band or if it's completely clear and that's going to tell you, big white band, you're probably a high salt sweater, completely clear, very little coming out. That's great and I can see the post on Instagram now, people showing their salt band from sweating. I mean obviously salt is so essential for so many physiological functions. You don't want too high or too low but if you're losing more it makes sense you would need to take in more. So half of my body weight announces as a just foundation of fluid intake. Coffee and tea could be included in that but that should probably be mostly water or things similar to it. And then during exercise, how do I want to think about this again? Let's say I'm a high salt output then I'd want to drink maybe 40 ounces of water or more. Yeah, okay. I'll do this easier. Let's talk about pre and mid and post. So what to drink pre? If you come in having hit these rules, you're okay and pre workout can be as little as like five or six ounces, basically a couple of sips of water. Fine. If you come in poorly hydrated then you maybe need to go more like 12 but here's the deal. If you start off a session in a bad spot, you're not going to catch back up. Like you're just you're in trouble. Let's say you come in you did you follow direction. 500 milligrams salt before 500 milligrams after a very easy rule. Pick whatever source you want. That's a couple of sprinkles of table salt. If you want Himalayan, that's fine. You don't have to. Himalayan is actually a fairly low sodium salt. That's not the best for for this purposes. If you're higher, salt or sweat a little bit more. If you want to go choose an electrolyte of which there are infinite, you can look on the packet and it'll tell you, you know, 250 milligrams per serving or 400 or 600 or whatever happens to be. But around 500 pre 500 posts is a very general rule. And then during is thanks to you, my famous galpon equation now that is all over the world. All I did is I took the literature and I said, okay. In general, the research shows pretty clearly two milligrams per kilogram body weight over 15 minutes seems to put you in a pretty good spot. Most people don't think about kilograms or milliliters. So can I just run that over and then turns out it's about your body weight divided by 30 analysis. Like that's all you have to. Body weight and pounds divided by 30. Yeah. Exactly. Right. So you weigh 200 pounds divided by 30 and that's number of ounces. You don't want to go every 15 or 20 minutes. So I'm getting that amount every 15 to 20 minutes throughout the training. And now in the weight room, that's pretty easy to do. Yeah. Because there are rest intervals. But people will need to do this while running or cycling. And that can cause a little bit of gastric distress if you're not used to it. Is that right? You can learn to run with it with some water in your belly. 100%. The gut is very trainable in a lot of directions. But in terms of fluid as well as carbohydrate, which is another thing that is going to get people. But that's a very trainable. It'll be uncomfortable initially, but you'll quickly get into it. A better solution for those folks. Just come in hydrated. And you might not even need any water. You could probably perform just fine. So the ones that don't have as much of an opportunity, you really have to emphasize walking in. We have this problem with like professional golfers. They have plenty of time to drink water, but they're so focused on the shot and there's a lot of variables coming up. Once they hit their shot and they're moving on to the next one, they're thinking about, I mean, they're going over a scorecard of 185 yards away. And I go 184 and a half yards, going to go 186 yards. What's the slope of that? What's the wind up here? What's the wind up there? Like they're just thinking and they just forget. Even though they have 4 and a half hours, so we have to make sure that they immediately get off the course. We go right into recovery as hard as we possibly can. They wake up the next morning. They're in a good spot. We crush recovery. And now it's like, if you can remember to drink this, great. If not, we're still fine. If it's not a big deal and you have time like in a lifter, because I deal with that problem with fighters too. We can only drink so much in the middle of a fight. A couple of steps over there, we can't go mix them. Two milliliters. It's like, can you get a couple of steps in? Oh shit, forgot. It's not going to happen. So we have to take more of an emphasis before and after. So start your recovery process immediately and then come in the next day. That's your window. And then whatever you can get in during the workout, that's fine too. If you're a higher salt sweater, set it to 500, 500, maybe go 750, 750. If you have a longer bout of exercise, and especially if it's hot or humid, then you might want to consider some salt in the workout as well. And 300 milligrams during the workout, totally fine. It's enough. If it is a really long workout and it's really hot and you're going to lose pounds during it, you need a specific strategy. If you're going to lose less than a pound, you don't need to worry about it. It's not going to be enough of a detriment for you to really care. So that's a rough rule. Now if you're 200 plus pounds, maybe that number moves from one pound to two pounds. But really the number we're looking at is what 1% of your body weight. If you're losing more than 1% of your body weight, we need to start caring. If it's less than 1%, it's not going to really pay that much of a difference. Okay, so for myself, because I don't get super technical, I don't wear any devices besides a wristwatch. Thanks. Yeah, very attached to this watcher. It's attached to me, I suppose. My body weight in pounds divided by two, that's what I'm going to try and get across the entire day as a kind of baseline. And then my body weight in pounds divided by 30 during the workout, every 15 or 20 minutes that I'm going to try and consume that amount. And then I definitely do better when I increase the amount of salt that I'm taking in, any 500 to 500 milligrams to a gram of salt several times a day actually. But I'm not eating that often, which leads me to my other question, which is I prefer to train fasted or semi-fasted, meaning first thing in the morning, or within an hour or two of waking, obviously I've been fasting while I'm asleep, or having not eaten anything for three or four hours before, I just feel lighter and more energetic. If that works for me, is that okay or should I try and is it better to eat something before one trains? Personal preference. Easy, easy answer there. It depends on, of course, how hard you trained, what the training was like, what's for you're involved with, how many telecoms is such, but in general, personal preference for the average person. That probably handles 90% of the questions about that. Cold. Cold showers, ice baths, and cold immersion up to the neck. I always preface this by saying there are not a lot of studies, there are some, but not a lot of controlled studies looking at cold showers because it's harder to control the variables of where people stand. I would say if you have access to cold immersion of some sort, ice bath or cold immersion great, but if you don't, cold showers would be the next best thing. The lower goes that if you do an ice bath or cold water immersion after strength or hypertrophy training that you are short circuiting some of that, the lower also goes that cold showers might be okay. My interpretation of those data and that discussion is that all that is probably true, but I have a hard time imagining that the effects are so robust that it can completely prevent strength gains and hypertrophy such that my stance for myself is trying to do the cold exposure training away from the strength and hypertrophy training, but if you can't do it any other time, right afterward probably isn't going to throw my whole system out of whack and prevent the improvements. Am I deluding myself? A couple of caveats, you're number one. I would say I have a personal vested interest in cold. I've been around this stuff for a long time, being involved and being an advisor for XPT and being in this space a long time, I'm a big believer in cold, especially cold water. Deliberate cold exposure. 100%. Right. So that being said, I do think getting into an ice bath immediately after a hypertrophy session is getting pretty close to you just should have done the session. It is detrimental. Good to know. I wouldn't do it. I guess is the most blunt way to put it. If you're like, hey, I'm not super concerned with growing muscle and I want these other things that come with cold water immersion. Fine. It's not zero. It's not zero. It's not taking you backwards. How much does it cut you down? I don't know. You don't know that that'd be a difficult number to come up with. Is it 1% reduction? No, it's more than that. Is it 100? Not even close. I don't know where it lands though. It's enough though for me to go. In general, best practices don't get in the ice immediately after a workout. How long should I wait? Well, in theory, the best answer we could give you would be four hours because of what we talked about earlier today of going, okay, immediately you've got the signaling cascade that takes seconds. You've got gene expression that's happening in this rough four hour window. After the genes have gone off and now you're just going through the protein synthesis process, the signal is already there and it's gone back down to baseline. So then we're introducing, or introducing cold here, it's not going to disrupt that signal. It's a very non-scientifically founded because we don't know at this point at all. What is very clear though is if you get off your workout goal right into the ice, it's probably 10% attenuation of growth. I don't know, maybe more depends on the person. Some people, if you look at the individual data, it's a pretty bad. It's enough to where it's like, that's a really big deal. The benefits of the ice, I don't think now outweigh the benefits of the hypertrophy training. What about cold showers? I don't think cold showers are going to do much. If you've been in both, that this is like, we're not playing the same game here. An ice bath or a true cold water immersion up to the neck with limbs in for one to five minutes is a completely different stimulus than in the cold shower. Especially also compared to a similar cryo. It's not even the same thing here. So in general, I would say, don't do those cold shower. I don't really care. Can you work it out so you don't do them same time? That would be my hope. I would actually prefer you to do the cold before. If you really had to do it, certainly we'll wake you up. Get that adrenaline burst. We've played with that actually years ago doing that. There's actually some fun stuff you can do with the endurance piece with cold stuff, but it's totally not feasible for most people because you're getting water everywhere. You're going to jump on your bike and just get shit. It's just a giant mess. It's fun. But yeah, I would say walk away from it if you can. That's actually where I stand based on the data. Based on my intuition and experience, I don't think it's a good thing to do. Now having said that, that's mostly concerned with maximizing hypertrophy. Strength is not as clear. There are some data to show at an actual block, strength adaptations, but because of what we talked about earlier, the mechanisms and the drivers are different. So I don't think it's as big a concern for strength development. Though I would still generally say if you can get away with staying out of the ice immediately after the workout and you can at least wait a few hours, that's the better approach. Less concern with strength, more concern with hypertrophy in terms of interference effect. If you can do it on off days or before or any other time, that's the place to land. That's generally when I try to do it. Just throwing out an extreme case because I get to ask that question a lot. What about the use of ice bath or cold water immersion or cold shower after endurance training? Okay. A couple of interesting things here. You mentioned we don't have a tremendous amount of data on cold water immersion overall. So a lot of this is moving. There have been some papers to show that cold water immersion can actually enhance mitochondrial biogenesis. And actually even for endurance stuff, it's been shown to cause improvement in endurance adaptations relative to not. It's not enough for me to be truly confident in that statement yet. I would like to see that repeated, not that I have a problem with the paper, the methodology that they use in that particular study, but it's just a weird thing. So I want to see this repeated more often. So I have less concern with doing it immediately post endurance because you could even argue that there may be some benefit. I don't think you need to go out of your way to try to make sure you get an ice immediately afterwards and thinking you're going to get some massive adaptation. We use ice a decent amount when I can get athletes to do it, but this context is different. Number one, when we're in camp and we've got a world title fight coming up or something else, we've just pitched in a major baseball game. I am not concerned about hypertrophy. I'm not even concerned with strength development. I am now pushing towards recovery. There's a paradigm that I think is important with all of these things to understand, which is, are you pushing for optimization or adaptation? When you're pushing for adaptation, you don't want to block the signal for adaptation. This means less recovery. You're not going to feel as good and you probably should be hedging towards stress. When you're pushing for optimization, it's the opposite. So if I'm in season and I had a picture just throw 125 pitches, I'm not trying to cause adaptation. I'm trying to recover as quickly as possible because four days from now, we've got to do this again. I've got to do this across 162 games. You're going to play five days in a PGA golf tournament and you're going to have to do it again every week for a bunch of weeks in a row. I need recovery as fast as I possibly can. So if I'm blending adaptation, fine, I'm not actually trying to do so. I'm trying to optimize. If you spend all of your time in one of those two areas, you're going to have problems. Do you need to be judicious about thinking, is this a point in my life or a training cycle that I want to cause adaptations or am I trying to optimize? You spend too much time in one of the other ones again, you're going to have problems. That's generally how I will treat the ice for all those adaptations. What about heat? Yeah. When I'll frame this question differently because I'm sure there are a number of ways in which heat can short circuit all sorts of things, heat in excess can kill you. It can shut down fertility. It can in excess. It can do all sorts of things, but it can also increase growth hormone, increase vasodilation, improve one's ability to sweat, which can be very beneficial in the number of contexts. For the typical, for 75% of people, 75% of the time, when do you think heat is most useful? I'm referring to dry sauna or wet sauna. I'm not specifically talking about infrared sauna because the data there are a little unclear to me. I don't even know that my sense with infrared, it's not as if they don't go hot enough for my particular taste. You and I have a similar taste there. We're not crushing 200 past. I'm not interested. Right. Am I sense about infrared sauna? Maybe I haven't seen the data. But that a lot of people like it because they like the way they look in the infrared sauna. It feels cool. It feels like you're doing something unusual. Red lights are beneficial for other reasons. Especially for mitochondrial health and the retinas, the good data. But infrared sauna to me, they never goes hot enough. So I'm talking about 200 or hotter, maybe 180 to 20. Obviously do what safe folks and heat all the warnings about pregnant people not going in size, etc. I assume you're lumping in hot water immersion. Hot water immersion. So hot baths, hot sauna. When would you like, when do you think most people could leverage sauna or hot baths to benefit their training and fitness and health? Yeah. I have a handful of things to say about this topic. One of them is you never have a hard time convincing people to get hot. Everyone feels good. Yeah, I get hot bath. Can you take more hot showers? Sure. No problem there, right? There are a handful of studies that have looked at this immediately post. And it seems to even augment hypertrophy. So after hypertrophy training, getting in the sauna for 20 minutes? Yeah, whatever. Whatever needs to be. You have a good titration. What's the number minutes wise? We don't have a temperature titration. Hot shower would be a second, that would be a week second best. I would say it's a very weak. So take a hot bath. I think a hot bath is probably a lot closer to what you're looking for. It actually kind of goes back to our initial conversations. Theoretically, you're just going to aid in blood flow. So you're going to put more nutrients and more waste product out, metabolic stress, all that stuff is going through. So that's the thought. Anyways, we'd far from no sense. Plosible, right? Absolutely plausible. I'm something people will do. Feels good. Let's say with cold and hot, I want to caution you against a couple of things. This is true across all physiology, but you need to be really careful about moving percentages from molecular to outcome. Very careful. So for example, it's easy to see a paper that says, okay, we put you in a hot bath or something and we saw growth hormone increase 300%. That is not going to result in 300% increase in muscle size. In fact, 300% might result in absolutely no change in a physical size. And the reason I'm saying this is because there's a lot of people in this space that will misapply the mechanisms. And they'll grossly overestimate what these things can do and what they do do because they'll find something like that. I mean, you know, this you've done enough cellular work to in the lab if I see mTOR doubled, I think shit, it didn't work. I need to see a 10X increase before I know it's even physiologically relevant. So reading that paper, reading someone's social media posts, you're like, wow, it increased mTOR 38%. I'm like, well, I didn't work. And you're like, wow, that's huge. I'm like, that's not 38% increase in muscle size. So that's a very important point I want to make because I'm going to talk about the benefits here in a second. But I do want people to be fooled into thinking that this is some crazy miracle and it's not a very good example. The same thing with the sauna. In terms of general health, health outcomes, it is a clearly a beneficial thing. This is a really good idea to get hot a lot. It is not a substitute for exercise though. It's a very important distinction. If the if the options are nothing or sauna, get in the sauna. Really, really good idea. If the exchange is though, I don't need to work out because I did the sauna. Bad. You this is not a winning solution. You and I know some maniacs that actually work out in the sauna. We do. I don't necessarily recommend that. That actually would probably kill a large number of people. But it can be worked up to it certainly. Yeah. So every time I talk about that, I flag that because it's just too easy to hit that and go, oh, I think Dr. Huberin said, if I just get in the sauna, I don't have to work out. No, no. Those words have never come out of my mind. I definitely didn't say that. And I'm definitely not working out in the sauna. The sauna, I'm either sitting or I'm lying down and I'm trying to make it through. I tend to do three 20 minute bouts across the entire week. So I aim for 60 minutes per week of heat exposure. Which is not a ton. If I said I've never worked out in the sauna. So you're one of those. Yeah, people will do air squats. They'll bring the airdine bike in there. I look at the sauna as kind of a time to get lazy and sweat. Totally fine. Going back to our question. So potential to aid plausible aid. We need to see more research on that to really get a, do I need to put this in practice? I think if you try it, very little harm. I struggle to see it downside. If you make sure your hydration's on point, right? Because now you got a factor in the fact you just kicked out two or three pounds. If you're at 200 plus pounds, I assume or roughly. If you're in the sauna for 20 minutes, I would imagine you can do two or three pounds. Yeah, usually I'm, I'm hover somewhere around like to 25. Yeah. And I drink, I drink at 32 ounce. Right. It's water with the electrolyte solution that's pretty high salt afterwards. And sometimes during. And sometimes after that, if I do it late in the evening, I'll go to sleep and I'll wake up in the middle of the night, just feeling so parched. It's amazing how much water one loses in the sauna. Like a normal sweat rate for someone to 25, especially in 20 minutes in a sauna, I would absolutely expect you to do three pounds. Easy without like really more. I should be doing more. Probably even more water. Yeah, you're probably half the water that you need to get. And you mentioned the possible benefits of doing it after strength hypertrophy training, which are makes sense for plausible mechanistic reasons and not know official data there yet. What about after endurance training? Assuming somebody hydrates well enough and they're not overheated from their endurance work. Yep. It could also be a benefit. Yeah. Wow. So more and more what I'm thinking the framework here is in an ideal world, one would train and then do sauna or heat exposure or some kind endurance training or strength hypertrophy training and then do sauna and then do cold exposure on. Off days or at least four hours away from the from any kind of training or if you had to do it close to train, do it before training. Yeah, I love cold in the morning. We've actually run this experiment on professional athletes. We do have tracking with things like HRB, which is a global metric of like overall fatigue. Okay. And you've probably talked about that before, but problems with it, but roughly idea of overall fatigue. HRB in general higher the score the better. Right. So low HRB is fatigue. Right. So if you wake up and take your HRB in the morning and then you get into ice, what's going to happen is you're going to see that number plummet. The second you get out, that's going to fall off the earth. What's means roughly you've moved into a sympathetic place. Surprising. You get in 30 degree water. You're going to go very sympathetic very quickly. However, if you continue to watch your HRB for 30, 16, 90 and up to two to three hours post, you will generally see an improved HRB score relative to where you started. So it's back to this hormatic stressor, right? A really cold shocking exposure will be a net result of you being more relaxed throughout the day in general. And we've seen that now like very consistently across years with athletes. So I think it's a great way to start your day. You won't need nearly as much coffee after spending three minutes in 30 degree water. 30 degrees is pretty darn cold. I was in the ocean this morning for about three minutes. It felt I didn't bring a thermometer, but it felt like somewhere in the low 50s. But 50 and moving is really cold. Yeah. Water is moving. That's really cold. That's right. The thermal layer that surrounds you when you sit still in cold water immersion, I'm encouraging people now if they really, I was the joke that people like to look real stoic and tough when they're in there. Like they're just grinding through with no pain at all. But the stillness is actually reducing the stimulus if they sift around a little bit. You break up that thermal layer. That's where the real action is. We've joked about this for years. Like do 50 degrees with a whirlpool jet on. Now I'm impressed. Because that is hard. You sit in 35 degree for three minutes. I guess. But with XBT, I've seen, I can't even tell you how many hundreds of people from all walks of life on all age that we've been able to get in 30 some degree water for three minutes. 50 degrees with a whirlpool going. That number gets very small. If you don't have access to a whirlpool, this should be reassuring to you. Some people say, I don't have access to ice. Ice can actually get pretty expensive. You're doing a $50 ice bath every day. You can fill your bathtub with cool to cold water. Get in. But just make sure that you keep sifting your limbs. It's chilly. The studies on the very well-established increases in dopamine and epinephrine that occur in cold water exposure. It's actually done at an hour and 60 degrees Fahrenheit. You don't necessarily need ice cold or an ice bath. But immersion is really better than the cold shower. The cold shower is kind of the espresso shot version. That's sort of funny because if you look at most of those initial studies and you think, man, how did they get people to sign up to spend 45 minutes in 55 degree water? 55 degrees is cold. Even if it's not moving. They're going to not spend five minutes in them. They're going to go an hour. If you've ever done ice baths at that temperature, you know, like, all right, after a few minutes, it's not that bad. But man, that's a protocol. Yeah. It's kind of a cold endurance protocol because one thing to get in for one minute to three minutes and you know you're getting out, you could sing a song. You could do anything to distract yourself. But 45 minutes to an hour is intense. Maybe they, I don't know. I don't think they paid the subjects. But anyway, that study was done in Europe. You think of where it was done. But anyway, they were, they were hearty subjects. Want to talk a bit about overtraining and gauging recovery. So there are a couple methods that I've heard about and that I use based on some data that I've seen, but mainly discussions with really informed people like yourself, Brian McKenzie, Kelly Starat and others. The two that I'm aware of for gauging recovery of the nervous system and kind of systemic recovery are grip strength, especially grip strength on waking in the morning. And the so called carbon dioxide tolerance test. The ability to do a long controlled exhale after a few rhythmic deep breaths, just which I'm assuming taps into both one's ability to mechanically control the diaphragm, but also how well one is regulating carbon dioxide. This question is, is this stuff fiction fact or a combination of kind of anecdata as I call it? Are there any peer reviewed published data as your lab working on these things and am I deluding myself using these tools or are they useful? It's not fiction at all. There are like CO2 tolerance, there's less published data. We've run a study in our lab looking at the associations between the CO2 tolerance and what we call it, trait and state anxiety. And those are in the publication process is what I'll say. Right. So you can't really talk about that stuff as you know and tell it's out, but in general, I'd say like, there's a reason I'm still doing it. I'll just leave it at that. Yeah, assuming it's not a clinical trial. I mean, I think sharing preliminary findings is fine as long as we highlight them as preliminary. Yeah. I'm not a reviewer, but I look forward to reading the paper. Yeah, but as you know, scientific, like you need to be careful about sending, telling people results before you've gone through that process. Right. Which is why I'm flagging this as these results are not yet peer-reviewed, pass through the peer review process. So you're hearing about it prior to peer review. Yep. Having said that, there's enough in that field. I'm not the first one into that field. And so I'm very confident that that's a real thing. I mean, in terms of actual tracking recovery, the big picture is this. When we run through a full analysis, when we have an athlete go through our biomelectic program, we're going to run and we're going to have three major categories. Okay, category one, we call visible stressors. And then we have hidden stressors and then we have recovery capacity. Anytime the total stress load outpaces recovery capacity, you're either going backwards in your physical ability or you're reducing adaptability. Now you have levers to pull here. You can reduce stress intake or you can increase recovery capacity, right? What we want in an ideal situation is you'll be able to implement the most stress possible because that's the driver of adaptation, recover from that. Now we get the most adaptation and adaptation being simply a change, whatever change you want to be. That's our gold standard, right? It's pie in the eye. Some people have endogenous differences. They just recover better. They don't. They're genetic factors. But let's talk about the ones that are manipulatable. If we go to the stress side of it, you want the throttle to be pushed as far down on the ones you want stress from and as far off of the ones you don't want stress so that the adaptation comes in the exact area you want and you're not burning gas and something you don't care about because you're just you're taking that total stress bucket too high. Recovery capacity over there. So here's how you can do that. You can run some analytics and measure what we do with everyone through these very comprehensive breakdowns to figure out what's that physiology look like hidden and visible and then what's the recovery capacity. Since we have that blueprint, we can now figure out what are the two or three things we need to track that are these indicators of what we call performance anchors. So an anchor is something that kind of drags behind you or below you that slows you down. The analogy being let's say we're going down one of these amazing canyon roads and I won't say which canyon we're in so you can stay hidden here. And your car is going down at a certain velocity and you want to go faster. Most people's is first impulse is to hit the gas and accelerator. We want to push. Well that's fine. But if your foot is on the break and you push the accelerator, you might go a little bit faster. But number one, you're wasting a lot of literal gas to go a little bit faster and two, you're burning your engine. You're going to blow the easier solution is just take your foot off the break. You're going to go faster by just stopping yourself. Then if that's not fast enough, we can hit the accelerator. Someone wants to just push down, right? More stimulus, more optimization, Bing Bing Bing here. Our first analytics are where are these performance anchors? What's dragging you back? What's putting down the break? I want to move those two or three things out of the way and now let's see how far you get. Oh, look at that. Your recovery capacity has gone way up. Your adaptations are happening faster now. Well, we can do more work because you're recovering quicker. So we're trying to figure out in those buckets and we have a whole host of things that we measure biomarkers and surveys and everything else that we go through to find out what's there. So after we've done that, now we're just going to track a few of these recovery markers along the way to figure out what's globally happening. So that could mean grip strength. I have some folks who we're going to test grip strength daily. Others we're going to look at HRV or combinations. We may look at performance metrics like a force plate. So you're going to do a vertical jump every single day and we're going to see what that's at. We've got a top test before, which is how many times you can tap your fingers as fast as possible. It's a rough indicator of central nervous system in a say one minute or exactly. And this is apps you can do on this like the tapest fingers fast you can. It's going to say, hey, you did 60 taps today and your average is 75. I like that because it taps into, huh, no pun intended into upper motor and around capacity because a lot of things like like grip strength obviously, I have to send the deliberate signal to my hand to grip. But at some point, the lower motor neurons are going to be taking over the majority of the work. So we probably want to end on whereas tapping is going to be repetitive. Sending of signals from upper motor neurons. Yep. So some of the athletes I work with, we track blood every day. We track urine every day. We track ideally a combination of subjective and objective mentors. Everything from how did you feel last night to environmental sensors or their bedroom, full PSG is going on running like actual sleep diagnostics, not or ring nothing against our, but like full analytics and some of them, it's as simple as how do you feel today and what was your vertical jump? Right. So we're going to put people in a position to succeed. We're going to figure out what's the lever that they need to pull as well as what's their aptitude, what sport they in, what can we realistically get away with. And some of them will take machines with them and we'll do blood every day and urine and all kinds of stuff. And some of them, it's a lot lower for myself. I'm not, as I mentioned before, I'm not a big fan of devices. I'm trying to wear the wrist watch. I tend to go off feel which is not, it's not the ideal objective way to gauge things. But part of my reasoning for this is my colleague from the psychology department, Dr. Aliyah Krum, has done some studies where they've given, deliberately given people false feedback about their sleep. So told people you didn't sleep very well or they've told people you slept really well and performance can be driven in the expected direction based on feedback independent of how well people slept or didn't sleep. Now that doesn't mean you can take someone that only slept two hours or was up every 30 seconds because of apnea and tell them they slept great and they're going to perform great cognitive tasks. But you can't take someone who slept very well, tell them that their recovery quotient wasn't very good and their output is going to be worse. That's my concern about a lot of devices out there, not to name specific devices, but it's still unclear to the general public what the specific algorithms are to generate these recovery scores. And so many of the things that reportedly track sleep aren't tracking sleep, they're tracking heart rate and breathing, which are correlates of sleep depth, but that's different. And again, I'm not knocking those out. I think the sleep trackers, if nothing else, have provided a forum whereby people are very conscious of getting good sleep. It's sort of like knowing the total clerk can take of your food, people go, wow, I'm actually eating a lot more than I thought. It's collaboration. Or less in some cases, but often the case is that it's more. So I think for the typical person, I'm wondering whether like myself, because I'm not a competitive athlete or certainly not a professional athlete, competitive with myself, I suppose, but no one else. Morning pulse rate, I tend to take when I'm waking. If I wake out of a really stressful dream, I might relax a little bit and then just take my pulse rate, kind of get a range and see if it's spiking for whatever reason. I don't tend to measure strength, although I've heard you can just use a classic scale. Yeah. And then the pressure scale with the Neal now old fashion or some other more technical devices, probably if there's a low-cost one. Yeah, they're all low on low. And then the carbon dioxide tolerance test. So we haven't really talked about that in specific ways. My understanding of it is it's four deep slow breaths in through the nose, out through the nose, and then a big inhale as max exhale and then time duration of exhale through the nose and then stopping the stopwatch at the point where lungs are empty, not necessarily as long as one could hold their breath. Can I get that right? Pretty much. Okay, and I guess we should credit you and Brian McKenzie. Yeah, those guys. Yeah, and the folks under Brian Zambrella for really establishing this as a really good metric. When and how can I use the carbon dioxide tolerance test to gauge, recovery upon waking, post-training session? Yeah. That would be a good time. Number one answer is whatever you do, do be consistent, so do it under the, like any good science experiment, do it under the exact same conditions as you can. That generally means somewhere in the morning, because that's when you're probably going to have the most control, most ability going. So yeah, like you would take any HIV or other metric, wake up, get into control, get stabilized, take your metric. Got it. It's going to be pretty good. Got it. Sodium bicarb. Yeah. Rumor has it and data has it that it can actually be a pretty effective training tool. Very effective. Could you explain a little bit about how it works and how one might explore using sodium bicarb to enhance training output in a couple of different contexts? Yeah, so there's a handful of these ubiquitously effective supplements for performance. Sodium bicarb and it's one of them. It's a very ingenious idea because it's so simple. Effectively, muscle contraction happens because enzymatic function occurs within a fairly specific pH range. Right? So if it gets extremely acidic, it doesn't like it. And so whether you're running through aerobic glycolysis or anaerobic or anything else, all these things require even ATP hydrolysis requires ATPase. And enzyme has to, the enzymes don't function while outside of this fairly special range. So what happens is generally fatigue, the sensations of fatigue are actually caused by some signal that, hey, we're starting to run out of pH or we're getting in the wrong range. You're not out of gas usually. You're not too low on oxygen. You're not running low on muscle glycogen yet. You're typically going to see signs or feel signals of fatigue way prior to that, mostly being pH issues. That being said, what if we could regulate pH better? Enter by carbonate, right? So without going too far into metabolism, effectively what happens is you take an inhale and you're mostly breathing in oxygen, O2. When you exhale, you're breathing out CO2. So the difference is you've gained a carbon somehow. Well, all of your carbohydrates in your body come in the form of long carbon chains. In fact, that's what a carbohydrate means. It is a one carbon molecule that has one water molecule attached. It's a carbon that has been hydrated. In the case of glucose, blood sugar, it's a six carbon molecule, right? In terms of fat, which are the only two places you're going to get most of your cellular energy, carbohydrates and fat, that is also a big long block in chain of carbons. So whether you're getting your energy from fat or carbohydrate, you're going to split those atoms. In other words, you've got six carbons attached to each other. In this part of chemistry, it's exorganic. So when you break that carbon bond, so break one of those carbons off from the other, that's going to release energy. Just like if you had a pencil in here and I snapped it, you go bang and pop. I broke the bonds that were connecting that graphite, the next piece of graphite, and that released energy because I put energy into the system, et cetera. Okay. As a result, though, we've now had, say, five or six carbons chain together. We broke one off the end, which is not how it works, but making the point. Now you have one free floating carbon, use that energy release to then go make ATP, to then go make your muscles contract. But now you've got carbon floating around. You can associate free floating carbon with being at a higher acidic level. It's not going to happen. The only way that you're going to go through this process is if your body says, do we have an oxygen molecule available that we can bind this to immediately? Yes, we do. That carbon attaches to that oxygen molecule. You can't just put CO2 in the blood because of what we just talked about. You're going to bind it through this bicarbonate process. It's going to go through your blood. It's going to go into the lungs. It's going to go back into its carbon dioxide molecule. It's going to go through the alveoli into the lungs and you're going to exhale. You went from carbon to this bicarbonate system back into carbon exhale. Inhaled O2 plants go the opposite, by the way. They're going to breathe in the CO2. They're going to cleave off that carbon, stack those carbons together, and that's how they get larger. In your blood, those six carbon chains are called glucose. If we store that in your muscle, we call it glycogen. We take a bunch of glucose and stack it together and a plant, we call that starch. That's effectively what it is. You take a bunch of carbon from the atmosphere, stuck it all together, and that's a starch. If you want to do it in the form of fruit, we take that starch from the ground. You put it up through the tree, go all the way up to the top, put it into the flower, break it up into these big, huge chunks of starch into little forms called fructose or glucose. That's why fruit has fructose in it and that's why tubers and stuff have starch in them. Basically starch in an animal is glycogeninous. Okay, all that to say, if that's happening, and we know that a byproduct specifically of anaerobic glycosis, meaning the breakdown of carbohydrates for fuel, typically in a very fast pace with low oxygen availability. The downside of that equation is acid production. We know that that's a problem because I started the conversation off there intentionally. What if we could reduce the acid buildup and how pH works, I went in double negatives there, right? You don't want too much acid buildup. Then could we prolong and sustain energy in a more effective pace, especially in this anaerobic, interval environment? That's important because in those things, failure is not a result of running out of fuel or oxygen. It's a result of fatigue building up way too quickly. Is that also true for resistance training? There's maybe more of the creatine phosphate system. That can be an issue. It could simply be an issue of force production. You just don't have enough force. At least you're not out of energy. You just can't muster enough force. You do enough reps, then it's going to be an issue there. Creatine phosphate would be the big winner depending. But come back a little bit to the beginning, then I'll encircling this altogether intentionally. The way that we produce energy is going to be in two primary categories. anaerobic, anaerobic, aerobic, meaning with oxygen and anaerobic, meaning without. In terms of muscle contraction, you're pretty much talking about carbohydrates or fat. Fat is going to be exclusively aerobic, meaning I'm going to use fat from the entire body roughly equally. You're doing a sprint up a hill and your hamstrings or your glutes or your quadron fire. You're not just going to use the fat that's directly in those hamstrings. You're going to lose it from the entire body. It has to go through liposis, so it's in this stored form, an adipose tissue. It's got to get broken down, put into blood. Blood's going to have to go through your body, get taken up into muscle, taken up through the muscle into the mitochondria. Then we're going to have to go through this process called bedoxidation. So remember, carbohydrates and glucose, especially as the sixth carbon molecule. Fat, if it's in the form of a tri-listeride, it is a three-carbon glycerol backbone and three, you know, tri-123 fatty acids. Three-carbon backbone and those fatty acids are just big, long chains of carbon. That's all it is, right? So we're going to break that thing down, put it in the blood, move it up, move it into our mitochondria. You can't walk those things across the mitochondria while they're too big. So what you have to do is leave them off in the little chunks and it turns out we break them off into two carbon chunks so we call it beta as in two. Move those into mitochondria. That can go through this little thing called Krebs cycle or triaxylic acid cycle and you kick out a bunch of energy out of that. You have two carbons, so as a result of that process, you're going to generate two carbon dioxide. But remember, you can only go to that process if oxygen is available because you have to be able to place those carbons onto something or acid gets up way too high too fast. This is one of the reasons why fat is a nice fuel source but it's very slow. It takes physical time to move from the back of your shoulder and your blood down your hamstring, uptake, uptake, uptake. In addition, it's required oxygen availability. If you need energy faster, you simply don't have the time to bring in the oxygen, transport it through, go through capillaries, exchange through tissue, et cetera. Carbohydrate on the other hand is going to be stored locally in the exercising muscle cell and specifically in the cytoplasm. That's glycogen. Asglycogen in the store in there. What's going to happen initially, your initial demands for extra fuel are going to come from the glycogen stored within the muscle fiber itself. It's just going to break right there and you're going to be off the races. You have the six carbon molecules, you're going to break it into two separate three carbon molecules. Okay, boom. That breaking provides you a tiny bit of energy, very small but some. Now you're going to take those two three carbon molecules and you want to be able to oxidize them because that's your only next step. In order to do that, you've got to go those into mitochondria. You've got to break one of those molecules off so then you'll be back to your two carbon molecules just like you did with fat. That's going to go into mitochondria and then it's going to go to the exact same crebsychle, two carbons, et cetera. But hold on. If you don't have sufficient oxygen or sufficient mitochondria availability and you're stuck at that two three carbon place, what do you do? You have problems, right? Now we have to say, okay, wait a minute. We have three carbon molecule and we have a bunch of this acid build up. Now acid functionally is hydrogen. That's what pH, potential hydrogen is what pH stands for, right? So if hydrogen is building up as a byproduct of muscular contraction attraction and then you're having this three carbon molecule, what it can actually do is grab one of those hydrogens and those three carbon molecules, by the way, are called peruvator, peruvian acid, right? If you take a peruvian acid and you grab hydrogen and put it on top of it, we now have a different name for it. It's called hydrogen peroxide, lactate, bingo, right? That's what lactate, lactate, and the acid is, right? So we've now built that up. So number one reason why lactate is not causing your fatigue is actually preventing it and that it does a bunch of other really cool stuff. But the point is that system currently lasts so long that gets overwhelmed very quickly. What are you going to do with the rest of this hydrogen? Well, if you started off in a normal pH range, you don't have very far to go before you've now gone into that level of too much acidity. If you started off in a more basic, and basic, I don't mean simple, I mean chemistry, right? And more alkaline. Then that same amount of increase in pH is no longer, now just puts you back in your physiologic array. So sodium by carbonate, whether taken as a cream or a powder or baking soda or anything else, can simply put you in a more alkaline state even acutely. So this is something you can take right now before your workout. You're going to delay what we call delay the progression of fatigue. And how would people start to approach this practice? My understanding is you can do this with common store bought baking soda. No question. There's always a concern about gastric distress that it's a very effective laxative, sometimes an unwanted laxative effect. But how would one approach this before? Let's say I'm going to, I'm doing the mile repeats, exercise, mile repeats protocol that we talked about earlier. I'm doing that for a few months and now I want to try the sodium by carb approach. I'm well hydrated, hopefully I'm well rested. I'm ready to go. When am I going to drink this sodium by carb solution? How would I make the solution? Let's say I take 10 ounces of water. How much by carb? Do I want a sodium by carb? Should I put in there? Can we come up with it? Is it half a teaspoon? Is it a teaspoon? Here's how I'm going to tell you. You will thank me by starting lower. You can always go more later. So a little pinch. You cannot go backwards. How about I start with a quarter teaspoon? Half a, honestly half is fine. Half a teaspoon. Totally fine. Disolve that. Slug that down. I read a study recently that showed that people will hit there. The peak benefits of this at different times, but it's somewhere, if memory serves me correctly, somewhere between 60 and 90 minutes later. So I might want to drink it on the way to the track. It can. It can be as low as 20. Okay. So maybe as I get to the track, since I'm going to do some warm up with some walk and jogging, I say 45 minutes. Okay. That's just a very rough standard. But yeah, you're right. It is individualized. And you probably want to play with that a little bit. If not, just somewhere and then a road of 20 to an hour. Okay. And then the perceived and real fatigue, if done correctly, the perceived and real fatigue ought to be reduced. Yes. I can do more work without feeling exhausted. Will I feel less of a lactate burn? Yep. Done in air quotes for those listening. I realize that's a very crude way to describe a complex physiological process. Yep. Fantastic. Can sodium bicarb be used repeatedly for longer duration training? Yep. And if I were going to use it with weight training for whatever reason, maybe I'm doing circuit type training or I'm doing the superset type strain training that you talked about before, push pull, push pull, which is a little bit more cardiovascularly demanding. Yep. Then maybe I'd sip that throughout the workout, make sure there's a bathroom nearby. It sounds like because I do, I am aware that many people get pretty serious gastric distress. It can happen very quickly. Okay. Great. Well, it sounds like an amazing training tool. I really appreciate you sharing it because I think it's one that doesn't get a lot of airtime these days because it's been around. But it sounds like it has some pretty impressive effects. Yeah. You know, it's sort of funny about that. I mean, I get it pop culture is what it is, but still to this day, if you want to talk about sort of your most effective general health slash performance supplementation, it's the same three to four to five. It's because they work really well. Without going into the chemistry of each one and the practice, these ones, because I definitely want to get you back to talk about nutrition and supplementation at some point. But I think we need a full couple of hours to get that right. Yep. If you, as a teaser, would you mind just listing off the other supplements that you have found are very effective for many people? So sodium bicarbore baking soda is one. What are some of the other ones? Yep. We'll go kind of reverse order beta-aligning is another very classically effective one. Similar idea of sodium bicarbate. So it's going to beta-aligning is going to come in. It's going to be converted and stored as what's called karnasine and the muscle and karnasine is an intracilular buffer. So in other words, it's just going to delay the buildup of acid. So fatigue blocker, if you will. So very effective, very cheap, very safe, well studied. The top one though of all of them by far that has an incredibly strong safety profile, it has, it is a cheap, it is a simple form to get, has an important magnitude of effect and is effective across multiple domains of physical health and performance. And it is because of that, it is my crown jewel. It is, in my opinion, without questioning the Michael Jordan of all supplementation and that's creating monohydrate. It affects so many things. We typically think about it as its muscle stuff, right? You talk kind of, you quickly were talking about the creating phosphate system. But we have to realize the mass majority research on creating phosphate is not in sport performance and has not been for 20 years. It's inclinical. And it has everything from effects on the neurological system to their, I've been associations to mental health and depression. And to be very clear, I am certainly not saying you can take creatine and cure anything. And I'm not saying it's going to stop you from depression or anything, but I'm saying there's, there's a lot of research in these areas and there's a reason people are doing it. Yeah, I completely agree. And if you're willing, I'd love to have you back for us to do a discussion on creatine and the brain or creatine and the nervous system. Yeah. And it's fun and maybe we can do a kind of a journal club and advance of that. For those that don't know, a journal club is where scientists read a bunch of papers and then argue about them, discuss them and try and extract the kind of, agreed upon center of mass, if you will. I think I've long been taking five grams of creatine monohydrate per day for mainly for the cognitive effects. Yeah. I sense an effect. I thought, at least the anachidate up, but I think there are a lot of data out there as you would. And I'm not, you're not crazy. There's enough there and in fact, there's enough mechanism now to understand the metabolic needs. People think the metamussel guy, right? So I'm going to think about the metabolism needed to fuel muscle. But we forget cells, immune cells, red blood cells, nerve cells, astrocytes, brain, all this stuff requires energy. And it's all going through metabolism. Super interesting. We will do the deep dive on that soon. I have a final question for you. You're involved in a really interesting, I think, really cutting-edge project that I first learned about from you. I don't know if anyone else doing anything as forward thinking and frankly, as relevant to the general population because of my interest in people getting better sleep and learning how to do that, avoiding stress and learning how to do that. Tell us a little bit about what I believe is called absolute rest. Right. So this is something that we've been playing with behind the scenes for a long time. And this is typically how high-performance stuff works, right? People want exclusivity and so this has been built. Effectively what happened is a friend of mine, Cody Burkart, I don't know if you know Cody, but a family. Down in Texas. Yeah. NASA. NASA guy. Yeah, I do know Cody. Wonderful. Just down the road thinker. Everyone's interested in sleep, right? And for forever, I would cover using with athletes, but everything available tells you how you're sleeping. Nothing can tell you why you're sleeping that way. And so we got together in Boulder and then I met some of his former colleagues, computer science folks, Harvard MD and some really impressive tech folks. And we were just thinking about an idea and we came up with, we started to realize the problems, right? And we just started to think about like, man, all the sleep tech is there. It's real. I don't need to convince people that they need sleep. Everyone's done that. You need high quality sleep, but how can I provide solutions? And with the people I work with, I can't just tell them your testosterone's down or your sleep's down or I need to be able to be like, this is down and here's why and here's our solution. That's how our high performance world works. So enter absolute rest. This is saying, okay, what are the actual nodes that go into high effective high quality sleep? Number one is psychology. So there has to be some sort of screening diagnostic for, are you not sleeping because of simply you can't control yourself and you've done a wonderful job of giving people tools. Or if you can't quite your mind before sleep to this, if you wake up and you can't go back to sleep here, a bunch of things, right? So we have some screens that we can do and there's some other stuff we can do to analyze. This is a psychological issue. Let's say it's not. You're under control and we have different tricks we use and stuff. And Jim Hack would talk about, but it's not that. Okay, is it physiology, which is no number two? Do we know what your dopamine levels are like? Do we know what your serotonin levels are like? What's melatonin look like? What's adrenaline? What's cortisol? Cortisol being the primary driver. What is this relationship DHA? Where are these things at? So we're going to measure all that and track that. We're going to measure that during the day, prior to sleep, we're going to measure that next morning and even sometimes throughout sleep. And we're going to figure out as a physiology problem. If it is, then we have clear corrections. If not, we're going to go on the next step, which is, is this possibly a pathology? So you have some sort of sleep disorder. We're going to run full, what's called PSG? So polycynography, a full, the exact same stuff you would get in a sleep clinic. It's a sensor that's going to go on measuring EEG and EOG and we're going to have muscle activation sensors to see if your legs are moving and everything else is going on. And we're going to get a full diagnostic and if anyone's ever done this, the amount of sleep issues that are happening in people that they don't even realize is extraordinarily high. So we're going to figure this out. One very quick example, we just did this with a professional athlete and he was having like 280 roughly of these episodes per night and to be categorized as an episode, you have to meet these four specific criteria, oxygen saturation, ventilation changes, brain changes, etc. And he hit that over 200 times a night and what this technology allowed us to do is figure out what position did all these things occur in. Well, in his particular case, most of them are happening with his own as back. And so we bought a very simple like pillow basically that went on as back that kept him from sleeping on as back and we saw an 85% reduction in sleep awareness issues the very first night. Now we did that testosterone eventually tripled after three months by just improving sleep and all we did is move him on to his left or right side. So huge improvements just by understanding where the problem occurred and why it occurred there. We didn't have to change hardly anything else. He had the basic hygiene stuff down and temperature and all that stuff and he had his chilly pad and all that to keep the thing cool. We couldn't fix it years by the way. This took us two years of just trying everything we're like, man, and it was just like I wish, wish we could get you to sleep better and we I pulled out every trick I knew and it's just as soon as we built this dinner, I'm like, oh my God, it's all he's not overweight by the way. He doesn't have any he's not ironed to fish and isn't have any of these other clonical symptoms that are associated with bad. Supplementation everything we've done a thousand protocols that fixed it overnight. So if it's not psychology, it's not physiology and it's not pathology, then the last one that people don't have any idea about his environment. And so what you don't realize is we have a box we can sit right next to your bed. You just plug it in. You don't have to do anything. And it's going to run full environmental scans. So it's going to look at the temperature in your room. It's going to look at the humidity in your room. It's going to look at the volatile organic acids. These are things that are seeping out from your mattress. It's going to look at particulates in the air and pulse of allergens and things that are floating around that are closing your nose off. So you can't sleep at night and now you're mouth breathing and you've talked a lot. I'm sure on the previous episode about why that's bad. It's going to look at your CO2 cloud. So we've talked, we've already set this point up, right? You're inhaling O2, but then you're exhaling CO2. While during the day and when we're conversing, you have quite a bit of force with that exhalation, right? But at night, it's just barely seeping out of your mouth. So what happens is CO2 sends to cloud up and build around your face and then you end up re-breathing that CO2. And this can cause a large number of sleep problems because you're simply re-breathing in the panic whether you fully awake or just kick out of a sleep stage, the CO2 around your face is a big issue. This stuff has all been known by the way with the astronauts for a very long time. It just hasn't translated into the commercial spaces. Of course, Condor or high performer space. So we can measure that as well. And then we can figure out, like for the most extreme, we can actually come into a bedroom and build an entire sleep optimization setup and control the entire thing. But for most folks, the minimum we can do is run full diagnostics and check off, is this environmental related? Is it pathology or something else? So is this a commercial device that people can eventually access? It is now. So where can people learn more about Absolute Rest? AbsoluteRest.com. Very cool. And just a very full disclosure, I wasn't aware that you had done this prior to today where you mentioned I was like to ask people scientists or otherwise, I was like, love to ask you, what are you most excited about lately? And this sounds like an amazing technology. And just to be really clear, that's not like something we're working on. That's landed. That's landed. We're ready to go. And that's one of the things I appreciate about you is that you're willing to sometimes speculate, but you always say it's speculation. But in general, you seem like the kind of guy where if you're going to be public facing about something, if you're going to make a statement, there's got to be quite a bit behind it. You're not going to elude to the in 10 years, we might be able to do this in five years. You're a very data driven kind of guy. Yeah. Well, the people I work with, we need answers. We don't have that time frame and we typically have like, hey, we start the season of four weeks. And then what's the time frame? Well, as I said, I appreciate that about you, but it is, but one of the many things I appreciate, I think the listeners and I can well appreciate on the basis of today's discussion, what a enormous wealth of information you are, how clear and, and potently you communicate that information. And also how you can take a huge cloud of information and still distill it into protocols that ought to work for 75% of people, 75% of the time, which is an immensely valuable thing to do. So for me and from the listeners, I just want to say thank you so much for taking the several now hours. I lose track of time, which is a good, reflects all good things. Several hours to take a break from teaching, take a break from research, take a break from the other important commitments of your life and really share with us all this incredible information. I'm so, so grateful. My pleasure, man, I'm glad we finally got to connect. This has been a long time in the making. It has and I'm going to, I'm going to bring the breathing protocols to my training. I'm going to start doing more of the endurance type and interuble type training. I'm going to start moving when I do heat. I'm going to start moving when I do cold. I might even start throwing some sodium bicarbon to a very small amount of sodium bicarbon into some water before I train and listen, Andy, Professor Andy Galpin. Thank you ever so much. My pleasure. Thank you for joining me today for my discussion with Dr. Andy Galpin. If you'd like to learn more about his work and learn further information about exercise science from Dr. Galpin, please find him on Instagram at Dr. Andy Galpin. You can also find him on Twitter at the same handle. Dr. Andy Galpin spelled with 1L. And if you're learning from and or enjoying this podcast, please subscribe to our YouTube channel. That's a terrific zero cost way to support us. Please also subscribe to the podcast on Spotify and Apple. And on Apple, you have the opportunity to leave us up to a five star review. If you have questions or comments about the podcast or you have suggestions about future topics or guests that you'd like to see me interview, please put that in the comment section on YouTube. We do read all the comments. In addition, please check out the sponsors mentioned at the beginning of today's podcast. That's the best way to support this podcast. We also have a Patreon, it's patreon.com slash Andrew Huberman. And there you can support the podcast at any level that you like. During today's conversation and on many previous episodes of the Huberman Lab podcast, we discuss supplements. While supplements aren't necessary for everybody, many people derive tremendous benefit from them for things like sleep and focus and energy and many other features of our physiology and mental functioning. There are some important issues to consider when considering supplements. One of those issues is the quality of the ingredients. For that reason, we've partnered with Thorne, THORne, because Thorne supplements have the highest possible standards with respect to the quality of the ingredients they include. If you'd like to see the supplements that I take, you can go to Thorne. That's THORne. R-N-E.com slash the letter U slash Huberman. And there you'll see the supplements that I take. And you can get 20% off any of those supplements. If you navigate further into the Thorne site through that website, Thorne.com slash U slash Huberman, you can also get 20% off any of the other supplements that Thorne makes. If you're not already following Huberman Lab on Instagram and Twitter, please do so. There I discuss science and science based tools, some of which overlap with the content of the Huberman Lab podcast, but much of which is distinct from the information covered on this podcast. Thank you once again for joining me for my discussion with Dr. Andy Galpin. And as always, thank you for your interest in science.