Dr. Andy Galpin: How to Build Physical Endurance & Lose Fat | Huberman Lab Guest Series

This is episode 3 of a 6-part special series on fitness, exercise and performance with Andy Galpin, PhD, professor of kinesiology at California State University, Fullerton. He explains protocols to improve the various kinds of physical endurance: muscular endurance, anerobic capacity, maximum aerobic output, and long duration endurance. He also explains how the body uses different energy sources (carbohydrates, proteins, fats) during rest and exercise. He also explains the mechanisms underlying fat loss and how and why exercise accelerates rates of fat loss. We cover the many concepts related to endurance training and fat loss such as metabolic flexibility, breathwork training for exercise performance and recovery, lactate production and regulation, how to improve blood flow to muscles, anaerobic vs. aerobic metabolism, exercise fatigue, low-carbohydrate diets and fat loss, and how to combine different types of workouts to improve overall endurance. This episode in intended for everyone ranging from novice and recreational exercisers to elite endurance athletes. Anyone wishing to improve their physical health and performance stands to benefit from the information.

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[, Music] welcome to the Huberman lab guest Series where I and an expert guest, discuss science and science-based tools for everyday life, I'm Andrew Huberman and I'm our professor of neurobiology and Ophthalmology at Stanford School of Medicine. Today’s episode is the third in the sixth episode series on fitness exercise and performance. Today’s episode is all about endurance and fat loss. That is the specific protocols required to achieve

the four different kinds of endurance and how to maximize fat loss. Dr Andy Galpin great to be back today we're going to talk about endurance and I'm very interested in this conversation, because I, like many other people, strive to get a certain amount of cardiovascular work in each week. Maybe a long-ish jog, maybe a swim ride, the bike, Etc. But when I think about the word endurance, the idea that almost immediately comes to mind is about doing something for a long period of time repeatedly. But I have a feeling that there are other ways to trigger this adaptation that we call the endurance adaptation. So I'm excited to learn about that. I'M also excited to learn about the fuel systems in the body that allow for endurance and other modes of repeated activity. So, in order to kick things off, I'd love for you to frame the conversation by telling us what is endurance and are there indeed a large variety of ways to induce what we call this endurance adaptation. Sure. The way I want to start actually here is is calling back to some of the things we talked about our previous conversations, which are really people exercise for three reasons: number one you want to feel better number two. You want to look a certain way and then number three. You want to be able to do that for a long time right, so you need the way that we say it in sports is look good, feel good play good right. So I want some sort of functionality to be able to perform a certain way whatever that is for you. You want to be able to look a certain way that, whatever that matters for you and then you want to be able to do that for a long time. So when it comes to endurance, we have a bunch of misnomers here, which is the same thing with the strength, training and resistance exercise side. Where we wanted to dispel this myth that I lift weights only because I I want to gain muscle or play a sport, and I want to do cardio, because I want to leave their loose fat or for long Health sake. And just like, we smashed that myth from the strength training side, I want to smash it from the endurance training side. There are so many other reasons that you want to perform: endurance training, regardless of your goal, right, whether it is longevity, whether it is performance or whether it is Aesthetics and so we're going to. I want to cover all those reasons: uh exactly what to do. Protocols of course, and why those things are working that way in general, though, the quick answer is really: endurance comes down to two independent factors. Factor number one is fatigue, management and then Factor number two is fueling and that’s all it really comes down to. So all the different types of training are going to reach a limitation which are either again your ability to deal with some sort of fatigue and that’s generally, a fatigue signal. The other one is managing some sort of restriction of energy input and a lot of the spoiler here is a lot of the times. People think it's a fueling issue and really it's a fatigue, management issue or the opposite and to have a complete Health Spectrum, regardless of whether you're a high performance athlete like I typically deal with or general public. You need to be able to do both manage fatigue. As well as understand fuel storage, so that’s really what we're going to

get into today, fantastic. I can't wait before we dive in I'm going to ask you what I often ask people who are expert in their respective fields, which is: is there any non-obvious tool or mechanism or tool, end mechanism that can allow people to access better endurance? You know when I think about training for endurance again, I think about trying to run longer and longer each week yeah or Swim further and further and so on. But I do wonder whether or not there are other forms of training that can amplify the endurance adaptation that I or most people, perhaps don't think of as endurance sure the way I want to answer this is if we look back and think about how we've answered That question with power and strength in force production, it is really about. How much can you produce maximally once what you're asking now is? How can I repeat that same quality of performance? If that's the case, endurance really comes down to your ability to maintain proper mechanics. That's going like the biggest way we can and increase your endurance exponentially very quickly is mechanical, and this is starting with breathing, and so we need to be breathing properly. We need to have proper posture and positions, and then we need to be moving well. Efficiency is going to Trump Force always for endurance. The other side of the equation is not that you can have a little bit of leaks in your mechanics and still squat well or jump high and be fine, because you don't have to suffer those consequences repeatedly right. That's going to drain you over time, so the quickest way to improve endurance is to improve mechanics and the mechanical thing I would go after. First is your breathing techniques, your pattern, your entire approach, as well as your posture and then from there. The third one would be your movement technique. Is it possible to describe the best way to breathe when doing an endurance training, or is it far more complex than that and if it is far more complex than that, then certainly we can get into it. During Today's episode yeah, it is both of those. I will give you a quick answer, though. A lot of the times you can kind of Hit the cheat code, which is nasal breathing, there's plenty of times. When you don't want to nasal breathe, you don't need your nasal breathe, but just again is that, like a one tool that is a for a pretty General answer, if you can do that a lot of the times that will fix breathing mechanics just by default, and We can maybe talk about why that is later, but that would be my sort of one sentence bullet point answer immediately of how to get in the right positions. The second one would be simply looking at your posture right, so whether you're on a bike or you're, doing a lift or you're running if you're, literally uh hunched over and your ribs are touching your femur or getting closer and closer like tends to happen on a Bike or an air assault thing for somebody I've seen recently this morning, I was on the assault bike, um doing a Sprint, and I asked Andy Dr Galpin to critique my form and anything else he wanted to critique so that I could improve, and he did comment On my rather c-shaped posture, correct, um, encouraging me to be more upright, which I should probably do now as well, and he also cued me to the fact that

during a one minute Sprint there is something that is quote unquote magic. That happens right about the 42nd Mark, and I use that as a um as a milestone uh to look for, and indeed something does happen at the 42nd, it's into a one minute Sprint, where all of a sudden it it does seem to get much easier. For reasons I don't understand, maybe you can to tell it that, but it certainly had nothing to do with my posture. My posture needs Improvement. Thank you well, yeah, so um, breathing mechanics and breathing strategies. Uh people tend to be over breathing early on and this is going to lead to problems later so having a more strategic breathing pattern and approach is

00:07:30 Tool: “Exercise Snacks”

That we're going to dive very deep into the mechanisms of Energy and Metabolism and endurance today. But as long as we're having a discussion about these um briefs or tidbits of how to improve endurance. Are there any other ways to improve endurance that that are of relatively short time investment, even if they require a lot of um energy? Sure the classic Paradigm you're going to find here is steady, state long duration posed up against what a lot of folks will now call higher intensity interval, training specifically and there's a lot of misconceptions here. The quick answer is, you need to be doing both and there's probably a bunch of stuff in between that you should be practicing. If you honestly want to maximize those three factories we talked about at the beginning, you need to be training across this full spectrum. Just like, I told you to train across the full spectrum of your lifting. We want to be doing the same thing here. So are there independent special factors that can happen with the shorter time length, higher intensity stuff? Absolutely there's also magic that happens on the other end of that Spectrum. So it's very important that people don't just choose one side because what tends to happen is people either go with the oh, I'm going to do 30 or 45 minutes of steady state stuff? That’s it or I'm going to, do the opposite, which I'm going to leave that stuff on the table. Not do it because I only want to do high intensity intervals, because I can get it done in five minutes, so there's Magic on both sides of the equation. We want to get into all that, but just to answer your question directly, there's a whole bunch of of things. You can do um in under one minute that are convenient to do and there's a wonderful set of papers out of a couple Laboratories in Canada that that championed this idea. That’s called exercise snacks. So there's a bunch of there's a series of studies that have been done here that are really interesting and they've looked at a couple of things that are noteworthy. One of them is a 20-second bout of all out work, and this is actually done in workers in an office, and so what they have them do is run upstairs and I believe it was about 60. Steps is

what it took them, something along the order of 20 seconds exactly, and they repeated that about once every four hours. So really it's you go to work. You get, you know, put your coffee and your bag down. Whatever you run up a flight of stairs 20 seconds later, then you go right back to work at lunch and before you go home, you sort of repeat it there and if you repeat that that's multiple times a week, you're going to do that, I think they In one of the interventions, it was three times a week for six weeks 18 total times. You did that and what you'll see is a noticeable Improvement. This is statistically significant improvements in cardiorespiratory Fitness, specifically VO2 max, as well as a number of cognitive benefits, work, productivity, Etc. That can happen in as little as 20 seconds. You don't have to go to the gym. You don't have to shower. You don't have to do anything like that. Just find the stairs run up and down them a few times now you may have noticed um you actually sort of caught me yesterday. I did that right here right, I was just I we had a little bit of a break. I was feeling an energy lull. I ran up the stairs three or four times felt a lot better, so that can actually also help. They ran another study where they looked at that following a giant high glycemic index meal and what they saw and then they took insulin measures and a whole bunch of um other biological markers Associated that you want to pay attention to the high glycemic index meal and They looked at those immediately an hour three hours six hours as opposed, and it was very clear that same intervention was able to improve post-planned, yell glucose control, insulin and a whole bunch of other factors. In addition to that. So if you are the sort of type who's like wow, I'm in an office all day, maybe also had a giant high glycemic index meal, not the best approach, but a little bit of mitigation. There can just be running up a flight of stairs or doing something like that for as little as 20 seconds. So there's a lot of magic and power and maximal exertion. If one does not have access to a flight of stairs at work, could they do jumping jacks? Absolutely I mean you could do anything. You really wanted. It'S not the mode of exercise that matters here. It is simply the exertion you just get up as hard as you can. You could do burpees. You could do any number of things. You could Sprint down your road down the hallway back and forth. The mode is is just uh, something that was easy for the scientists to control and X number of steps. People could do it, you're not going to fall, hurt yourself things like that. Just to remind me it's once every four hours, one minute of all 20 seconds. Oh 20 seconds excuse me uh 20 seconds of essentially all out exertion yep, while remaining safe, not going so fast up the stairs or doing jumping jacks, certainly not down the stairs up the stairs. Please um escalators don't count well, I suppose they count if they're uh, you know if you're, if you're moving uh, if you're not remaining on the same steps, um. In fact, in an airport recently I saw somebody walking against the oh there you go the conveyor yeah while talking on the phone while waiting for their flight to take off, and I thought it's genius right. It looked a little awkward who cares yeah, but it was. I have

looked awkward in every airport. I'Ve been in for the last 15 years for those exact reasons, doing wild stuff like that yeah well, nothing's, more Awkward than not being able to walk to the end of the terminal, simply because one isn't familiar with walking that far carrying a couple of suitcases there. You go yeah, that's the the other fit test. The suitcase carrier yeah, I'm in the airport. I love this so once every four hours 20 seconds. So maybe once when arriving to work once four hours in and then four hours most people probably work somewhere. You know eight plus or minus two hours now. One thing I actually really want to make clear because your audience is so incredible um they tend to be really excited about these protocols and they follow them exactly as written. That's not exactly how science works, so it doesn't necessarily have to be every four hours. It'S in half three three times a day. It doesn't have to be 20 seconds. They literally built that protocol, because it was so they're trying to replicate a real life scenario. Maybe you're in an office building you're generally there for eight hours, Let's see if you did one every sort of so if you want to do it four times a week great, if you can do it only 10 seconds, amazing you're, probably going to get the same Benefits those are not the details to pay attention to the detail. To pay attention to is every so often multiple times a day. Try to get your heart rate up really quickly, it doesn't require sweating, doesn't require anything else, there's no warm-up associated with it again. You need a minute break in between meetings or whatever, and you can Sprint up them. I do this all the time in my house when you, you know, have those days when you're on, like seven straight hours of zooms, Etc. You can get out of 20 seconds. I run to my garage, which is over there. I hop on the the airbike and I will just smash out 30 seconds as fast as I can and then walk right back in love. It yeah, I'm going to start yeah. Just also you can just put one of those things which I do also just

00:14:21 Momentous, Levels, LMNT

and hop over right over there you know the whole entire thing now literally takes 23 seconds before we begin I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford it is also separate from Dr Andy galpin's teaching and research roles at Cal State Fullerton it is however part of our desire and effort to bring zero cost to Consumer information about science and science related tools to the general public in keeping with that theme we'd like to thank the sponsors of Today's podcast our first sponsor is momentous momentous makes supplements of the absolute highest quality the Huberman Lab podcast is proud to be partnering with momentous for several important reasons first of all as I mentioned their supplements

are of extremely high quality second of all their supplements are generally in single ingredient formulations if you're going to develop a supplementation protocol you're going to want to focus mainly on using single ingredient formulations with single ingredient formulations you can devise the most logical and effective and cost-effective supplementation regimen for your goals in addition momentous supplement ship internationally and this is of course important because we realize that many of the Huberman Lab podcast listeners reside outside the United States if you'd like to try the various supplements mentioned on the Huberman Lab podcast in particular supplements for Hormone Health for Sleep optimization for Focus as well as a number of other things including exercise recovery you can go to live momentous spelled ous so that's livemomentis.com Huberman Today's episode is also brought To Us by levels levels is a program that lets you see how different foods and activities affect your health by giving you real-time feedback on your blood glucose using a continuous glucose monitor many people are aware that their blood sugar that is their blood glucose level is critical for everything from Fat Loss to muscle gain to healthy cognition and indeed aging of the brain and body most people do not know however how different foods and different activities including exercise or different temperature environments impact their blood glucose levels and yet blood glucose is exquisitely sensitive to all of those things I first started using levels about a year ago as a way to understand and how different foods exercise and timing of food relative to exercise and quality of sleep at night impact my blood glucose levels and I've learned a tremendous amount from using levels it's taught me when best to eat what best to eat when best to exercise how best to exercise and how to modulate my entire schedule from work to exercise and even my sleep so if you're interested in learning more about levels and trying a continuous glucose monitor yourself go to levels.link Huberman that's levels dot link slash Huberman Today's episode is also brought To Us by element element is an electrolyte drink that contains the exact ratios of the electrolyte sodium magnesium and potassium to optimize cellular functioning for mental and physical performance most people realize that hydration is key we need to ingest enough fluids in order to feel our best and perform our best but what most people do not realize is that the proper functioning of our cells and nerve cells neurons in particular requires that sodium magnesium and potassium be present in the correct ratio goes now of course people with pre-hypertension and hypertension need to be careful about their sodium intake but what a lot of people don't realize is that if you drink caffeine if you exercise and in particular if you're following a very clean diet that is

not a lot of processed foods which of course is a good thing chances are you're not getting enough sodium potassium and magnesium to optimize mental and physical performance element contains a science-backed ratio of 1 000 milligrams that's one gram of sodium 200 milligrams of potassium and 60 milligrams of magnesium and no sugar if you'd like to try element you can go to drink element that's lmnt.com Huberman to get a free element sample pack with your purchase

00:18:01 Endurance Categories

Again, that's drink element, lmnt.com Huberman, to claim a free sample pack. So tell me about endurance. What is endurance, how do I get more endurance and how does it work when we think about endurance? I would like to open up the conversation to include more things than people generally do when they hear the word endurance. So if we just think about what you typically ask your body to do or would like to ask your body to do, and we just walk through them, it's going to be things like this number one I want to have energy throughout the day. That's actually a form of endurance. Great, I don't want to have these lulls and fatigue, and I want to feel fantastic as I move throughout my activities of daily living, whatever those may be work exercise enjoyment, paying attention, focus all that stuff. Great, that's one thing. Another thing you want to ask your body to do is I want to be able to repeat some small effort in a muscle group and not and feel great about that. This is what we generally call muscular endurance. So this is something like I want to be able to walk up those 10 flights of steps, and my quads aren't burning at the end of it right or it even gives me energy. Another thing you'll want to ask your body to do is to be able to perform a tremendous amount of work for a longer period of time, something in the realm of you know 20 to 80 seconds. So this could be something like if you're surfing and you've got to paddle extremely hard for a minute to get on on top of a wave or you want to. You got you're out riding your bike and you need to be able to get up a hill and it's a very Steep Hill. These are going to take maximal efforts for some small amount of time and then you'll get back up there. We tend to call that maximum anaerobic capacity so that the max amount of work you can perform at a higher rate for some amount of seconds to like maybe a minute past. That is your ability to repeat an effort, kind of like that for something like 5 to 15 minutes, and this example would be run a mile right, some some interval like that, which is a longer distance right. That is going to be your maximum aerobic capacity. Okay, another thing you're going to want your body to do is we call sustained position so this is you want to be able to sit in your chair at work and have perfect posture for 20. 30. 40 minutes right. You want to be able

to stand in line at a grocery store for 15 minutes and not have a breakdown in posture, so you want to be able to maintain position when you're riding your bike. You'Re not collapsing you're doing any of these activities and you don't get hurt or lose efficiency simply because you couldn't sustain basic positions, all right, whatever those shapes and positions need to be okay and then the last one is a maximum distance. So you won't be able to go for a longer hike or have just a long day at Disneyland for whatever it needs to be and feel great at the end of it right. So the goal with all of these things is not, can you just do them, but can you do them and then you feel good afterwards, so we're back in a right position where they give you energy, you feel good about it and it's not just something you Had to do and you regretted and you felt awful so those are the factors I think about when someone says I want better endurance. Is I want to walk backwards and say? Okay, when you say endurance, what do you mean and that’s generally the things I've come across as if you can handle all of those things you're going to feel like you're in fantastic shape, you're going to feel your recovery? Is going to be excellent and your physical performance in the gym or in any of the sporting activities you do will be enhanced, given what you told us a little bit earlier, that endurance really reflects fatigue and management and energy production. How do each and both of those things relate to endurance at a mechanistic level? So really, what I'm asking is, what is fatigue management and what is energy production in order to do that? It'S important that we understand all of those functional capacities that I just talked about. They all have different points of failure. Okay, so, in order to then work backwards and say well, how do I optimize my performance in all those categories? We need to go through each one and figure out. Where am I failing? Some of them are going to be failing because of fatigue management, and some of them will be failing because of energy production issues. So if we walk through a little bit of how we make energy and how we handle fatigue, then we're going to have a better understanding of exactly what to do for each one of these categories. If you feel like one of them in

00:22:16 Fat Loss & Respiration; Carbon Cycles & Storage, Metabolism

Particular is worse for you or lagging behind, or if in general you just want to improve all of them all right now I want to make a little bit of a 90 degree turn here. I'M going to do it with strategy, though I promise - and I want to ask you a very simple question: how do you lose weight? I was taught that the calories in calories out thermodynamics of energy utilization governs most everything. That is, if I'm ingesting less caloric energy than I burn, then I'm going to lose weight and if I'm ingesting exactly as much as I burn I'll, maintain weight and if I

ingest more then I burn then I'll gain weight. Sure that is the approach you would take. What I'm asking really is, how are you actually physically losing the weight, so my understanding is that we have different fuel sources in the body glycogen, which is stored in muscle and liver body, fat, which is sort of mainly white adipose tissue and which is subcutaneous and Around our organs intra visceral fat and that we can also use protein as a fuel and then, as I recall, there's also a phosphocreatine system. And I think you're going to tell me that each of these systems is tapped into on different time scales. And perhaps according to different levels of exertion and I'm certain that what I just said is not exhaustive, but hopefully it is most or entirely correct, pretty correct. What'S that got to do with fat loss at some point body, fat stores, adipose, adipocytes fat cells are going to start liberating fat as a fuel source and the stimulus for that I'm assuming is going to be that other fuel sources are either depleted or that the Energy and metabolic systems of the body - I don't want to say, decide because they don't have their own Consciousness, but are um. Our flip signals are signaling in a way that registers that body fat would be the optimal fuel source. Given how long or into and or intensely a given activity has been performed? Okay, we have some stuff to clean up there, but we're still not really answering the question. How am I actually losing that body fat uh? How is it actually leaving the body correct uh? My understanding is that it leaves the body through respiration. Aha. So now we have some interesting things to talk about. How am I actually losing fat via respiration? What the hell does that even mean? How is something that occupied this physical space on the side of me? Leaving my body through my mouth - and that is a very clear answer there right, which I'm sure you're queued up to when you take a breath in you're generally breathing in oxygen O2. That’s some other things, but we'll just stick to oxygen when you exhale you're, breathing out CO2. The difference between those two is that carbon molecule well, one of the things that’s important to understand here is all of your carbohydrates, which is that word itself is a carbon that has been hydrated, so it is a carbon molecule attached to a water molecule. It is a simple chain of carbons. Your fat molecules are also chains of carbon. All of metabolism really in terms of energy production, is simply trying to figure out a way to break those carbon bonds. As a result, we get energy from that. We use that energy to create a molecule called ATP, which is the central source of energy for any living being right. That carbon is then floating around in free form, which is bad news internally. So we've got to figure out a way to get that carbon out of our system, so all of energy production - all of fatigue management really comes down to this core issue of how are we handling carbon and how are we moving it around the body? And so what we do is we do this sneaky thing, so another question I'd like to ask people is: why do we breathe well for two reasons, uh to bring oxygen into the system and to offload carbon dioxide, but the neural trigger for breathing is when carbon Dioxide hits a threshold level and the set of

neurons in the brain, stem and elsewhere, uh activate the phrenic nerve or the gas reflex or a combination of things, and we inhale or inhale right. So a reduction of oxygen intake generally doesn't stimulate ventilation unless you're at altitude, then that sort of changes right in general. It'S an elevation in CO2, that's going to stimulate breathing off. The only reason you bring in O2, for the most part, is to get rid of the CO2 oxygen is not a fuel source, it is not a way and it works the same with fire by the way. So you know you have to have oxygen present for a fire to go and if you use quelch oxygen, the fire will go out right. That's about half of um how those like fire extinguishers work, but we think then that means oxygen is the fuel. It is not the fuel, it is something entirely different. It is a necessary Pro. It is a product that is necessary for the metabolism process to actually occur all right, so we're kind of dancing around an idea here, which is this carbon cycle of life. So what happens in plants is, they generally will breathe in the opposite and breathe out the opposite of humans, so a plant will breathe in CO2 and exhale O2 all right. This is why we have to have a certain amount of these things and algae and forests and trees and stuff to maintain this O2 CO2 balance in our atmosphere. We do the opposite, so we have this wonderful circle of life. We breathe in O2, breathe out CO2. They do the opposite. Well, what happens is because carbohydrates are long. Chains of carbon and fats are as well generally when we think about fats by the way, it's important to understand that structure a little bit. So if we think about triglycerides, it is a three carbon backbone chain of glycerol, so one two three and horizontally running off of each one of those are fatty, acid chains right. So we form this structure that looks like an e right like the letter e three in the back and then three chains coming off of it. Each of those chains are called fatty acids and each of those fatty acids are a length of carbon right or a number of carbons strung together. However, many carbons are there determines which type of fatty acid. It is right so stearic, acid, linoleic acid, like any different number of things. It'S also what determines whether or not it is a monounsaturated or polyunsaturated, as if carbon requires a special thing, called a double bond. So if there's a double bond across every carbon and carbon, then they're all fully saturated and you're great. If there's any of them that are not double bonded and in fact an example. If there is one that doesn't have a double bond that is now called Mono and saturated, if there are many, it is called polyunsaturated. So there's pros and cons to all these things right in either case we're still talking long carbon chains. So what a plant will do is bring in carbon, and then it has this wonderful ability to use energy from the sun called photosynthesis, and it can take those carbons that it inhales and use the energy from the Sun to form a bond. Now, in our prior discussion, when we're going over hypertrophy, we talked about the energy that was required to go through protein synthesis. That's because forming a new atom or a new bond between atoms oftentimes takes energy. In this cases it does. The same thing happens

here. So if a plant does not have oxygen or does not have carbon dioxide in the air, it has no fuel. The basically think about it is that's what it eats. It needs to get nitrogen from the ground in the soil. Just like we need to get nitrogen from our protein, but fuel wise. It needs to get carbon dioxide. Then it needs sun to give it energy, so it can actually form that Bond right. That's what it's getting its fuel from all right. So if we think about um, a classic uh plant produce the plant that produces either a starch or a fruit, here's what happens it inhales that carbon and it starts packing it away now in a root vegetable. What it does is it stores those things together and if we store that thing and we grow fruit at the bottom of it, we tend to call those things starches, all right. It'S going to then take the carbon that is packed away in its root and send it up the tree, and it's going to actually do that by breaking it down into a smaller form of carbohydrate, that we tend to often call things like sucrose and glucose it'll. Ship that up the tree, it'll go out to the leaves and it'll convert it into the fruit, and it's going to eventually transform that stuff into smaller carbon things called fructose. And if we think about the fruit are the sugar in fruit. It'S often in the form of fructose or sucrose or a combination and sometimes glucose. So we have these smaller carbon six carbon chains generally in the form of glucose that are being made from this larger storage of uh carbohydrates that we call um starch right. So it's packed in together, your body does the exact same thing. So if it's a potato and it has a whole bunch of glucose packed away, we call that starch. If it's in your quadricep and we pack about a whole bunch of glucose Away, We Now call it glycogen. If it's in your blood as that six carbon chain, we call it glucose. If it's in the tree and in the fruit we call it fructose right. Those are different molecules, but that's effectively the same thing happens, so the biology or the chemistry is almost identical. It just runs in the reverse order, and that's why again at tubers and potatoes and stuff tend to be starches and fruits tend to be glucose. Fructose of sucrose, so we have this a wonderful Circle of Life. The plants can survive on just breathing in the CO2 and then getting the energy from the Sun. We don't have that ability, at least to my knowledge, to run through photosynthesis. So the only way we can get carbon into our system is to actually ingest carbon, which means we have to eat the starch, the fruit, the animal, some other form of stored carbon, to get that into our system. We then pack that away we put the carbohydrates, as you mentioned earlier, either on our liver, our blood or in our muscles. We put the fat generally in adipose tissue, we'll put a little bit in muscle cells as intramuscular triglycerides, and then the protein will use as structure right to do different things. We don't like to use protein as material or fuel, it's better used as structure, and what we have to do, then, is if all of a sudden, we realize that storage is getting too much in our body, in other words, we're gaining too much weight. We have to figure out how to get the carbons out of our body, and that is metabolism right anytime we're trying to break a carbon bonds, though

we can get energy to make ATP that’s going to release the carbon out of our tissue into the blood. We have to bring in oxygen to bind that carbon molecule to make CO2, so we can exhale it and put it back into the atmosphere. It'S a beautiful description of the circle of

00:33:08 Exhalation Rates, Exercise & Fat Loss; Calories

Life and energy utilization in the human body. I have to ask the question that I'm sure many people are wondering about, which is, if indeed, we exhale these carbons and as it relates to Fat Loss. That is the way that we lose fat if we're in a sub caloric state, for instance, has it ever been explored as to whether increasing the duration or intensity of exhales can accelerate fat loss? I mean that’s sort of The Logical extension of what you described and here I'm actually interested equally in whether or not the answer is yes as well as whether it could be no because I could imagine if the answer is yes well, then there's some interesting protocols To emerge from that, but that if it's no, it will reveal to us some important bottlenecks about metabolism and energy utilization. You ever seen those magicians who like show up and uh they can tell your mom's name or something like that before you, because they can sort of hold you down a path. Yeah, I mean not to take us down a deep dive tangent, but I once went to the Magic Castle in Los Angeles, and I was one of the people called up front and a in an incredible magician, a named um. I think his name was Ozzy mind or something uh. I think that’s right had me write my name on a card in a Sharpie pen. I ripped up the card. I ripped it up. I put it in my pocket and at the end of the 10 or 15 minute bout of him doing a bunch of other tricks. He asked me to look in my right shoe and under my foot in my right shoe was that card intact, yeah and it was no longer in my pocket and I swear in my life. I wasn't a a collaborator with him and to this day it still gives me chills because it well. I I don't know how magic yeah right magic. Well, the reason I say that is I've given that little Spiel and I just gave you the countless times on my glasses and I would say 99 of the time as soon as I stop. The very first question is so: can I just like do a bunch of exhales and lose fat, which is wonderful because I was really hoping you would do that and you rolled right into my trap right. You landed perfectly so I look like a like a a magician over here. I feel like. I should look in my right shoe right now. No, I asked the question because it's the logical extension of what you laid out, but I know biology to be um. Both uh, diabolical and cryptic, but also Exquisite in the way that things are arranged, and you don't get something for nothing. There are no free passes in physiology. That’s the saying, no free passes. The answer to your question is yes, 100. Yes, in fact, that is the only way to go about it. You have two options: you can ingest less carbon or you can expel more carbon

people always say calories in calories out. It'S really carbon in carbonate. That’s what a calorie is Right, calories, the amount of energy we get per breaking a carbon Bond, so it's really Less in less more out less in is fairly obvious, whether that comes in any form and by the way. This is exactly why the percentage of your intake coming from fats or carbohydrate. It doesn't really matter that much if you look at fat loss clinical trials, you guys may have covered this when Lane was in here. I'M sure like this is something he talks about a lot. It doesn't matter it's irrelevant, because it's not about that. There'S nothing magic in those things they are different. They have different physiological responses. Everything is different, right, no duh, but in general it's just simply about carbon intake turns out fat has a lot more carbons per mole than carbohydrates. Do so there's more calories per mole in there. So if you, the physical amount of fat, needs to come in as a smaller amount physical amount of carbohydrates - these are coming, it will come in as a larger amount, but you can play any number of very high carb low fat. What matters total calories right again. It'S not like the only thing that matters, but you know what I'm saying some percentages in the way can go. Fat loss Works, fantastic, high fat, low carbohydrate. Why? Why do all these things work? Because that’s not about that? It'S about total intake of carbon total Expo. So absolutely can you lose fat by simply exhaling more? In fact, that is exactly what you did this morning when I hopped on the airline bike. When you did anything right, the question is: can you think of a scenario in which you could have a bunch of increased rates of exhalation that helps in Fat Loss? Sure I can think of a lot of things that will stimulate increased rates of exhalation. One thing could be simply going right, and so the question is like: can I literally do some breath protocols where I force exhale and lose fat, and the answer is yes, but what happens what happens if you do hyperventilation training? Well, my lab studies. Cyclic hyperventilation is one of our many uh deliberate protocols and one of the most prominent things that one observes is that levels of adrenaline increase very quickly. Extremely quick people feel jittery anxious stressed and unless they are consciously trying to Anchor their thinking about what that means and the benefits that to persisting typically, they abort the cyclic hyperventilation protocol really quickly within seconds right. You will feel tingling sweating all kinds of things, you're hyperventilating right and we could. We could talk a nauseam about how that changes, everything from adrenaline to focus to a whole bunch of things. So, unfortunately, a strategy of sitting around just exhaling more than you inhale technically helps you lose more fat, but it's not going to last very long. So then the question is well. How do I get no situation or scenario in which I can increase my rate of expiration, where I'm not going to pass out? I'M not going and altering hypocapny and hypercapnia issues. Any idea of a situation in which you would have an enhanced rate of explanation without worrying about passing out sure a steady state exercise or not steady state exercise, lifting weights intervals. Moderate

training repeated any of these things. They all work equally for fat loss because all they're doing is increasing respiration rate they're, saying increased demand for energy increased exhalation, that’s the trick here and when you equate these things to that they have equal success in fat loss. It doesn't matter theoretically, where you're getting it from, and so when we get into this idea of well, what are the best training strategies for fat loss? It doesn't matter which one of these tactics you pick as long as you maintain a consistent adherence over time because of this exact fact. It doesn't matter if you're burning quote unquote fat in the exercise session or, if you're, burning carbohydrates in the exercise session. It is totally irrelevant to your net fat loss over time. Okay, now there's some significant misconceptions there about what I just talked and I would love to come back and walk through that in more detail. But that’s the main take-home message here. It won't matter what's coming in and it won't matter what's coming out because in either case it is the same rate of oxygen in and CO2 out. That’s the key metric, and hopefully this helps a lot of people have some relief because they're, like man you're so tied up on what is the exact protocol for training for optimizing fat loss? What'S the exact nutritional intervention I need for fat loss and then you wonder why all these different diets can work effectively and wonder why all these different training protocols - you know, surely you know somebody who lost a bunch of weight and the only thing they did? Is they just started running? There was no Advanced protocol, they just started running and they ran five miles every day that works and then tons of people who tried that and like didn't lose anything and lots of people who went to. I went to cardio kickboxing class lost weight. Oh I just started doing intervals on my law. Why? Why mysteriously you'll do all these things work they had. You have something had some spidey sense have to has to be going off in your brain, where, like there has to be something linking these things and what's linking it is simply carbon Exchange, so put yourself in a position in which you are exhaling more than you And inhaling without passing out, the other problem is, if you were to Simply do a breathing protocol, while the rate of exhalation would go up after that, you would correct and go in the opposite direction. So that’s the problem. Is your net carbon? The output over the course today is not going to change unless you increase the demand.

00:41:47 Cardiovascular Adaptations, Cardiac Output & Maximum Heart Rate

For energy and that’s how you get into that negative state along these lines of exhaling carbons as the route for fat loss, it makes me wonder whether or not increasing lung capacity is possible. I'M guessing the answer is yes, and whether or not increasing lung capacity is a

good goal and route to enhancing fat loss. Essentially, what I'm asking is, if you can offload more CO2, okay carbons per exhale. Are you a more efficient fat loss machine? It'S a wonderful thought and the answer would be no, not something you worry about, because if you were to Exhale more carbon than actually needed now, we're in a state of inefficiency, you're, burning way more energy than needed to do your activity. The heart has a metric called cardiac output. This is in Sciences. We abbreviate this as Q. For some odd reasons. It'S either seal or q and cardiac output is heart rate, multiplied by stroke volume. So it's how many beats per minute you're having as well as how much blood's coming out of it, so cardiac output is actually very specific to energy needs if you try to work around that, it's just going to adjust itself. So what I mean by this is, if you were able to increase your stroke volumes the amount of blood coming out per pump. You would automatically adjust reduce your heart rate so that you keep cardiac output exact to energetic demands, so you're sort of pushing one end of this of the spectrum, but your body will pull the other one back to keep you at that exact, same neutral level. So if you look at, if you think about like cardiovascular adaptations to endurance, training and any type of endurance training, a common thing, people will understand is resting heart rate, and so what that number is is just how many beats per minute you're having when you're sitting Here doing nothing, a very positive adaptation is a lowering of that resting rate over time as general numbers. What you will hear is people will say things like a normal resting heart rate is between 60 to 80 beats per minute, and you know if any of the things I've talked about um with the individuals I work with. I don't work with anybody with disease, just to clarify that I don't do anything with disease management treatment, anything it's always about people who are in a good spot who want to optimize or get to the next level. Whether this is professional athletes trying to to Peak for physical performance or uh, the folks in our rapid Health, optimization program that feel good again, it's not disease stuff, and they want to feel incredible. One of the metrics we're going to pay attention to is this resting heart rate? So here's what happens as you improve your endurance, your resting heart rate will go down. If I see somebody over 70 beats per minute um unless something's going on you're not physically fed, regardless of whether or not that is quote unquote within the normative values, I want to see. Everybody'S sub 60 beats per minute or close right, and that does not a difficult thing to really get to for most people. So if you train a lot, regardless of how you train intervals, steady state doesn't matter that resting heart rate will come down, but since energy demands at rest haven't really changed, cardiac Alpha stays the same. So what happens is stroke? Volume goes up so literally, like we trained your quadriceps on the Legacy engine machine to get stronger, so you can produce more Force per contraction. The heart will do the exact same thing, and so, as you're able to get more of the blood out of your heart per pump the heart realizes, I don't

need to pump as often so that’s the compensatory adaptation which is saying, hey, look. I don't need to beat 60 times a minute. I now need to beat 55 times a minute because I'm getting the same amount of Blood Out per pump chill, and this is why your resting heart rate goes down your resting stroke. Volume goes up, but your cardiac output is identical. So that’s not a good metric of Fitness. It'S going to stay the same. Cardiac output will only adjust for energetic changes, all right energy requirements in the acute moment right. How much do I need go, which is going to be determined by ventilation right? How much air am I bringing in and putting out that’s going to determine cardiac output and that’s going to determine where we're at? If you were to do like a sub maximal exercise test when you were unfit to when you're fit or when you're fit the way you're super fit at sub Max you're, going to see the same thing, cardiac output will be identical and you're like damn. Nothing happened. What you're, not realizing, is your heart rate at that same workload is now lower and that’s efficiency, because your stroke volume is higher where it gets. People tripped up is at Max because you may not see much of a change at Max because you won't really you don't really see an increase in maximum heart rate with Fitness. That’s not a thing right. So maximum heart rate is not a good proxy for fit or unfit, or anything like that. Stroke volume will get limited eventually by filling capacity of your heart. It has to have so much time to fill up with blood before it can contract again and squeeze the blood out and when you have a heart rate of 200 beats per minute. That just doesn't leave much time to fill, and so it won't really push you past that so don't worry about trying to increase your maximum heart rate. That’s not necessarily a good thing and it won't really change, but your cardiac health will because stroke volume will be higher, but that doesn't necessarily mean that I should avoid training that gets me up toward maximal heart rate. Correct

00:47:03 AG1 (Athletic Greens)

oh you should absolutely do it right that’s what that was my assumption I'd like to take a brief break and acknowledge our sponsor athletic greens athletic greens is a vitamin mineral probiotic and adaptogen drink designed to help you meet all of your foundational nutritional needs I've been taking athletic greens daily since 2012. so I'm delighted that they're a sponsor of this podcast the reason I started taking athletic greens and the reason I still take athletic greens once or twice a day is that it helps me meet all of my foundational nutritional needs that is it covers my vitamins my minerals and the probiotics are especially important to me athletic greens also contains adaptogens which are critical for recovering from stress from exercise from work or just general life if you'd

like to try athletic greens you can go to athleticgreens.com Huberman to claim a special offer they'll give you five free travel packs and they'll give you a year's supply of vitamin d3k2 again if

00:47:55 Excess Post-Exercise Consumption (EPOC); Exercise Intensity & Fat vs. Carbohydrate Energy Utilization

You'D like to try athletic greens, go to athleticreens.com Huberman to claim the special offer getting back to energy production and metabolism. So we've got these different modes of moving energy, but making and breaking energy Bonds in the body moving energy into different tissues and out of different tissues, and indeed out of the body through exhalation. How do each of these different modes of energy utilization relate to different modes of movement and exercise yeah in my mind, I'm starting to draw a bridge between okay. When I walk for 60 minutes, you know if I'm talking, I'm breathing a bit more. Maybe I'm burning a little more fat after all, speech is a modified exhale, um and amazing. If I'm sprinting um breathing differently and if I'm um, you know doing a 30 minute. Moderate quote: unquote: moderate jog, breathing differently, so you've beautifully Illustrated this bridge between energy production and utilization and carbon dioxide offload through exhalation. What are some of the specifics about energy utilization according to different modes of exercise, and if we could better Define modes of exercise or types of exercise that trigger specific adaptations? I think this is where the the bridge will move from being a a mere line to a real structure. Yeah, absolutely I want to lay one more foundational piece and then it's going to be much easier to understand the limitations I put on some of these training protocols, as well as the lack of limitations. Okay. So it's really really important the way I want to start this is we have this this Foundation now of of carbon and and basic energy production? That’s not to say, there's no difference. There is and that difference is important, but maybe we can answer the question from earlier, which is actually something you asked me this morning when we were exercising you're like training, fasted right does training fasted enhance fat loss and the logic is sound. If I don't have any fuel, then I should be burning more fat. Therefore, I should be losing more fat. It'S sound. It'S not true. Is this great idea? It'S one of these classic things in science and exercise physiology where, like sounds good, turns out. It'S not. It'S. Actually, a pretty gross misunderstanding of metabolism, so it's not to pick on that topic. I don't really care about that topic, but it is a it's a common question. It also gives me an opportunity to just tell you more about metabolism. So here's what happens: you're breathing in O2 and breathing out CO2. However, the ratio to that is what we call the either

rer respiratory exchange ratio or RQ respiratory quotient and I'm not going to differentiate those two they're not the same thing. But we're going to skip past that for now, as you begin to increase, exercise intensity, the percentage of o2 to CO2 rises in the favor of CO2. So you start breathing out way more CO2 than you are breathing in O2 right. And so, if we were to look at that number, you know once the relationship Echoes up so at rest. Most people have a of a value that we would typically call something like 0.6, okay and that's again, the relationship between O2 and CO2, maybe 0.7. If you were to go for a walk that increases slightly because you're now expiring CO2 at a higher rate, so now you've moved up to say 0.8 or something like that. One of the ways that we Mark somebody of achieving an actual VO2 max on a test is if that value exceeds 1.1. Now any of you who are paying attention are thinking, wait a minute how the hell can a ratio between two things ever get past one? Well, that's because you're getting in a place where you're actually offloading more CO2 than is actually necessary, and this is what actually causes and explains a thing that people like to call Epoch, which is excess exercise post oxygen consumption. This is another way to think about it. The only reason you're breathing is to bring in oxygen when offloads CO2 right, if I'm no longer exercising. Why am I still breathing? In other words, once you stop the demand or the need for for energy, you should stop ventilating, but you don't right. That's because, in the case of low intensity exercise the second, you stop you're right back down to resting ventilation, no problem, because you were able to match the need for energy with the offload of waste one to one during that exercise. When you start creeping up the intensity, you can't do that, so you have to basically start stealing a little bit of fuel here. So, even though you're done exercising you're still ventilating, because you have to pay that back and pay that back by that, I specifically mean you have to bring in oxygen because you have a whole bunch of waste. That's been accumulating in your tissue that you've got to deal with and I'll walk you through. What that waste is it's a particular molecule that a lot of people have heard of but grossly misunderstand, so you got to be able to handle that. So the reason that you sit there and go and continue to ventilate is because you're now trying to pay back that excess post exercise oxygen debt. That's that oxygen debt, we're specifically talking about all right. So that being said, as we start cruising up, that RQ starts going up up up up up up up and if we get to one your 1.0 you're you're in a like you're hurting you're in a pretty good spot. All right. I, like that you're hurting you're in a pretty good spot, yeah a window into Dr Annie galpin's mind. Now you really want to be a subject in his uh. His laboratory study sure masochists swarm to Andy's lab absolutely all right. So the idea that I will lose more fat by being in an exercise situation that is burning more fat. It seems to make sense, but it's a massive failure to understand the metabolism. It'S the exact same explanation to like exercising fasted doesn't matter, so the exercising fasted issue under normal circumstances is irrelevant

because you have plenty of fuel in the system, even when you haven't eaten breakfast that morning now, if you're talking like extended fasting over multiple days, this Is a different scenario: if muscle glycogen, liver, glycogen and blood glucose are at sufficient levels, then you absolutely have enough energy to perform almost any type of exercise that most people are doing. You know, maybe, if you're Rob and you're at Mile 20. Today, it's a different story, but the vast majority of us have plenty of fuel sitting around, so we're not going to burn more into fat um just because we didn't eat breakfast that morning, so that just doesn't make energetic sense. We have a lot of backup supplies. You'Re never out the trick here is this is there's a there's, a concept here. We call crossover concept so as we are starting to move up exercise intensity, we start burning a higher percentage of our fuel from carbohydrates and a lower percentage of our fuel coming from fat. I'M sleeping that's the highest percentage of your fuel that will be coming from fat of any activity you could ever do so. If the theory that I'm going to stay at a lower intensity to burn more fat was true, the optimal fat burning strategy would then be to sleep like that. Doesn'T make sense, of course it doesn't. So why would then going at a slightly elevated rate? Somehow? All of a sudden magically make you lose fat. It doesn't actually make sense when you think about that where you're like, oh yeah, there's no way so it's a percentage trick, it's a difference between absolute and relative. This is what this confusion is. So, yes, as you start doing, lower intensity exercise whether you're faster than audit, it's irrelevant, but lower intensity exercise, a greater percentage of your fuel is coming from fat. However, your total fuel expenditure is very low so that whole total carbon balance is not really being shifted. Much as you start exercising at a very high intensity, you actually start getting a higher percentage of your fuel from carbohydrate and a lower percentage from fat. In fact, at rest about the highest you can get in. Most people is about 60 of your fuel from fat. As you're sleeping, you might be 70, but you'll never be in a position ever no matter. What sort of thing you've heard on the internet you'll never be in a situation where fat is your only fuel source, the highest I've probably ever seen, is like 70 percent um. You should probably beat about that. That's a kind of a good number to think um. Honestly, but people will understand a little bit about metabolism to be dangerous, but not enough. We'Ll we'll throw out these terms like fat, adapted and fat adapted is a real thing, but is a massive misunderstanding oftentimes right it is this idea. Thinking like I can get into a spot where I'm maximizing fat, burning, maximizing fat, burning and maximizing fat for exercise and maximizing fat loss over time are not the same thing at all. Right, that's the confusion. So if you enhance fat, oxidation and exercise that does not enhance fat loss per se right, so this is a lot of the confusion. That's happening right so, as we start moving up, we can never get in a position where we're using fat only as a fuel. Again, at best you're at 70, fat, 30 carbohydrate for a lot of reasons we probably just don't

have time to get into today. However, the opposite is possible when you get into true high intensity exercise, you'll be basically 100 carbohydrate and zero percent fat. All right. That is very possible. That in fact, is 1.0. That's what our Q 1.1 is actually because your ventilation got so high. You actually exceeded that number, even though you're at 100 carbohydrate. This is what people came up with the idea. Then it's like whoa. I don't want to burn carbs, I want to lose fat, so my response to that is always like. Okay, great so it makes sense. Burning fat, losing fat, burning, carbs is losing what then, like you, think, your liver shrunk like wait a minute? What did you lose? Then where'd it come from it's all coming as carbon, don't worry about where it came from for your fuel. It just has to come out as carbon right. There are differences in exercise, efficiency for performance with our professional athletes, of course, but if the only goal here is phallus, it doesn't matter where you get it from the last Bridge we have to connect here is like well wait a minute if I only burned carbohydrate How did I actually lose that fat there was there? Was that love handle sitting on the side of me? How did that come out of me if I never burned that from my fuel, what you're, failing to understand is there's a balanced game that happens here. So if you were to do a bunch of high intensity exercise, training - and you burned only muscle, glycogen and blood glucose - and maybe even you did it for so long - you burned some liver glycogen. The body understands that it has expelled a lot of energy. From that side of the equation, it's going to do a couple of things. Now it's very difficult to go through this fancy situation, where you convert carbohydrates into fat and back and forth, like that's actually like fairly hard, what's easier to do with something you said earlier, is actually just bias energetics to a different fuel source. So in that scenario, where you're down really low in your carbohydrate carbohydrate stores, any carbohydrates you bring in are going to go to storage, and since your net, energy expenditure is something that your body regulates a lot any fat that you then bring in is going to Be utilized as a fuel source because it knows it doesn't need it anymore, that is in excess. So that's how you actually use fat

00:59:35 Tool: Training for Fat Loss, Carbohydrate Stores, Liver Glycogen & Fatigue

As a fuel, because you've burned down carbohydrate storages as I'm hearing this uh a couple of things come to mind. First of all, thank you for that incredibly important description of what is otherwise a very confusing landscape for most people. One of the key points I took away - and I just want to say from the outset this is not exhaustive by any stretch - is that burning fat does not equal losing fat from the body correct and then burning fat has to be divided into burning of body Fat stores and we need to distinguish that from burning of

dietary fat that is brought in correct oftentimes people don't disambiguate those correct and I'm also understanding that reducing one's body, carbohydrate, stores, muscle glycogen, liver, glycogen, Etc occurs during high intensity exercise yep as well as other Ways, but that is one very efficient way to tap into those stores which makes me wonder again. This is one of these things that does it lead to a protocol, makes me wonder whether or not doing high intensity, let's say weight training for 45 to 60 Minutes 75 minutes of strength, training, power, training, hypertrophy training, which we've covered in an episode about those topics And then doing some steady state cardiovascular exercise is there any benefit to that arrangement? That would quote unquote enhance body fat loss from the body to be very specific now, because, unlike the idea that training fasted would shift the bias towards fat loss, which it doesn't you've told us under those conditions, muscle glycogen and maybe even liver, glycogen is going to Be depleted, put simply, can I enhance body fat loss by doing some cardio after a bout of weight training if you equate for total energy expenditure, it won't matter now that you did bring up a very important point that I want to clarify. If you look at the exercise modalities that we laid out in our previous uh conversations, we talked about nine different adaptations. One was skill and then speed, power, strength, hypertrophy, muscular endurance, anaerobic capacity, aerobic capacity and long duration, endurance, speed, power and skill. Development have almost no benefit for fat loss because remember those are low weight, a lot of rest and low volume they're not really really going to be helpful. You can make a little bit of a case for strength a little bit, but the total energy expenditure for strength training, even if it's an hour, if it's truly strength, training it's fairly low because the repetitions are in the one to three range. That’s exactly it's not enough for total work. So, if you're trying to develop a protocol that sort of optimizes fat loss, what you want to do you were close in my opinion, is: do a combination of something in the hypertrophy, slash, muscular endurance, strength, training, realm, okay, so um six to Thirty repetitions, something like That resistance, training, great deplete muscle glycogen, maybe even a bit of liver glycogen, maybe a little bit depending on if you're doing it for a long time, but probably not a noticeable amount. Okay, so an hour of of uh hypertrophy type training if you're training hard with low responsibils - and you really did an hour - you would for sure get there, but most people don't because the reason why I crave large bowls of oatmeal and rice after I do weight Training yeah and replenish muscle, glycogen totally right um. Then you maybe do a little bit of very high intensity. Maximum heart rate well overview to Max uh hard, as you can for 20 30. 45 60 seconds. Something like that with some recovery. A lot of recovery and repeated, and that’s going to do a great job of replenishing muscle, glycogen right. If you do that long enough, you'll get the liver, but again most people, don't because it's really really hard to go that hard, so liver is sort of. Last Last Resort yeah basic mechanics here which

will which we'll actually get into as our like third segment here is. Energy production comes from the local, exercising muscle, first and foremost, from phosphocreatine and carbohydrate stores, right and so again, and we store it in a muscle. We call it glycogen right. That’s it's your first sign of light on defense. If you need glucose outside of that you're going to start pulling it from the blood, but one of the things your body regulates a handful of things over almost everything: blood, pH blood, glucose blood pressure and electrolyte concentrations like it really does not want to mess with Those things at all, it will change almost anything else in the body to keep those things standardized right. You generally, because you need all those things for your brain to work and your brain will stop working right. If you lose blood pressure, it won't go up. There pH changes, you can't run metabolism, electrolytes change, you can't think, and glucose is a primary fuel source for the brain. It'S going to be a problem right. So if that number starts to come down because you're grabbing glucose out of the blood your liver is going to, then kick in it's going to break down its glycogen to put glucose in the blood to keep the blood number the level. In fact, one of the things you'll see is blood. Glucose concentrations rise during exercise. They don't fall. In fact they rise as an anticipatory state. If you train a lot, your blood glucose will start going up before you start moving. It knows it's coming right, so you you can play that game. You can rob Peter to pay Paul for a long time and tell your liver runs out and that’s what actually is a bonk in terms of like long duration, endurance, stuff, you're talking many many miles. Several hours, typically, we say: oh, it's got to be over two hours before your liver starts to become a real problem, or it has to be tremendously intense because of those reasons you have to burn through just a lot of energy before your liver starts to get Into a problem, you can continue to train when your muscle, glycogen levels are low. In fact people say glycogen, depletion and muscle, but it's it's generally misnomer and you are going to have tremendous signals of fatigue when that number gets lower than 75 percent. So people think that, like their muscles are getting heavy you're, probably still 75 full a lot of folks will quit around the 50. The highest I've ever seen is like 95 true depletion and that’s an extremely high level cross-country skiers and like they're deltoid, it's very, very low. Some very talented Runners will get fairly low in their quads, but the vast majority of folks, by the time, you're 50 depleted you're going to quit it's going to be really really challenging, so you're never really going to get that low. It'S like a bit of a protective mechanism right, but when your liver gets low, you're going to be shut down and that’s the case of if you've ever been to like a marathon and you've seen, people run like 25 and a half miles. And then they just like Bonk they go into like baby deers walking stands and then they collapse and you're like how are you mentally weak, like you ran 26 miles, and you can't run the last point: it ain't mentally weak. It is if your liver is done. It'S going to. Stop you because there's no more backup reserves, muscle you can get away with you can push

through it. Liver will not let you go any farther. I find this fascinating because it makes me wonder whether or not the liver being depleted sends a neural signal to the brain or the brain must register some signal like I would like to be alive tomorrow. Thank you. Whatever is happening right now, um stopping is going to be safer than continuing yeah, and so that stop signal um is is one that I think a lot of people, including myself, are, are intrigued by because we always think that it's uh related to willpower, but the Brain needs to preserve itself and as the master computer I mean there are ways to go into kind of automaton type um. You know not thinking just doing type uh Behavior, you have override switches right and you can play those cards and you can get better at learning and be being less sensitive to that switch. That's exactly what happened when you first start training right. You start to realize, like oh my gosh, I'm super tired. Then you realize really quickly like. Oh I'm totally fine here, and this is like the pick pick your person who's made sayings like this, but it's like you're, really only 10 percent depleted or 30 or 40, or something we're all operating 40 of what we could do. Of course, any of those things are true because it is like a little bit of an override um, you've, just gotten very sensitive to being a small percentage. Depleted and you've learned. Okay, I'm tired - and there is a long way to go past that, but once you get past that and you flip that override switch a lot um, you just you're going to break quickly because you basically learn to ignore that signal and problems can happen really quickly. After that, and that's even experienced endurance athletes, if you hit that level, it's like you're going to be hitting the

01:08:01 Metabolic Flexibility, Carbohydrates & Fat; Exercise & Flexible Fuel Utilization

Concrete next and that's, you know, potentially a problem. I want to make sure I understand a concept that you referred to earlier correctly, because I have a feeling that I don't and that's this issue of how the body accesses body fat stores when in a sub, caloric State and I'm doing mainly glycogen burning exercise yeah. What I heard you say and please correct me where I'm undoubtedly wrong. What I heard you say was that okay, I go into the gym and I start lifting weights. I'M burning muscle, glycogen, mostly local, to the muscles that I'm using and then I start pulling glycogen from the bloodstream. Maybe there's some body fat stores that are mobilized, probably not dipping into my liver, glycogen. Okay, I complete the workout. Maybe I even hop on the air dime bike and do a little Sprint. Yeah go for a jog, maybe um I eat immediately afterward. Maybe I don't eat for a few hours afterwards, but across the day I ingest fewer calories than I burn. Is it the case that body fat is mobilized in order to replace the glycogen that my sub caloric intake was insufficient to provide, in other words, because I didn't eat enough to fill the glycogen stores? Am I using body fat converted

into glycogen to fill those stores right and, if so, is that a case where I'm no longer exhaling carbons in order to burn body fat, but rather I'm repurposing body fat into muscle? Have I turned fat into muscle in that case yeah I'm really glad uh. You asked this because I did a very poor job on that last Point talking about earlier, I'm realizing playing back in my head, because that's so many really good questions. You cannot turn fat into muscle. Can you turn muscle into fat? No, I'm so glad. You said that, because when I was in college yeah our I don't want to out that person. The physiology teacher seem to think still at that point that one could lift weights get muscular, but then it would eventually turn into body fat that that I, that myth has, I think, largely been dispelled. I heard that so many times as a kid. I heard it so many times in college. I heard it so I hear it so many times in our uh undergraduate students from other faculty and such so um, no like they're, not the same structures. They are very different um. Let me take you out on answering this better you're really really close so yeah. If you were to do that type of exercise where you've burned a lot of muscle glycogen, how is it I'm losing stored fat right? That's really! The Crux of the question - and it doesn't even actually matter if you then went ahead and ingested carbohydrates or fat post exercise. That's not really a thing you hit on a couple of key things number one. This is all under the assumption that total caloric intake is still low right. You have a total need. It'S below. Okay, I also want to flag calories in calories. Out is not the only thing that matters. This is a very complex thing. Calories in is incredibly complicated. Calories out is even more complicated. Okay, so we just maybe another series we can spend on that alone. All right! So don't don't go nuts about that. You have to be hypocaloric one way or the other. If you burn a bunch of muscle glycogen and you are hyper, caloric you're still going to add fat, if you burn a muscle, glycogen and you're hypochloric you're going to lose fat right, think about it. This way, you're in a negative calorie state. Where are those calories going to come from? Are you going to reduce your muscle, glycogen storages permanently? No, no. Are you going to reduce your glycogen storage in your liver? No, you want to reduce blood glucose no, no way right. So, where is that extra energy coming from it's coming from your stored fat? It is your backup, Reserve Energy System um. The way that I want to fly this here is people tend to think about it as like: carbohydrates versus fat. That's not it's more like a chain more like a bicycle. Where there's a front gear and a back gear. You turn one gear. It turns the other one. These are complementary systems, they are not and or systems right, you're turning one and when we go through carbohydrate metabolism, maybe here in a second you'll understand why you have to have an anaerobic and an aerobic component to that. There is absolutely no way to complete carbohydrate metabolism without oxygen. That has to happen. The only way to engage in fat metabolism is aerobic and oxygen. There'S no anaerobic component to it. There'S a fundamental difference there, so the your carbohydrates are meant to be

incredibly flexible. It is the primary fuel source for a reason. Your fat is not meant to be flexible, it is meant to be Unlimited. That's the basic point, so you want flexibility over here and an unlimited capacity over there. Now I'm safeguarded against any energetic need. Okay, I need to run up a hill for safety, cool carbohydrates are there. I need to then run for 17 hours. Cool fat is there. We want both of these systems. You want to be able to have great energy throughout the day. You want a slow drip. Coming from fat, you don't want up and down up and down, feel great up and down awesome. You want to be able to think very quickly and get hyper focused boom, carbohydrates, ramp right up right, get it into the brain, get thinking better, get thinking clearly fast. So we want all these not just for exercise purposes for, but for activities of daily living. We want an optimal system here and when people use the terms like fat, adapted they're generally hijacking that and they're thinking it used to be a thing. We said all the time and like all of my undergraduate classes for years, and that idea of metabolic flexibility is using optimal fuel sources and optimal types, not maximizing fat usage. The people have co-opted that term of metabolic flexibility to be like. Oh yeah. Yeah therefore, learn how to maximize fat burning. That's not what that term means. That term means maximizing your ability to use whatever fuel is optimal in that time now, I'll Grant you most people aren't fantastic and using fat as a fuel source relative to the other direction, but nonetheless, the the gold standard here should be maximizing both all right. Finally, answering your question: if I were to to burn a bunch of muscle glycogen, how am I losing that fat? Well, the fuel you're ingesting in that hypochloric state is going to say, hey look. We have a lot of muscle glycogen. We have to replenish so any carbohydrate that comes in needs to be biased towards storage. It'S got to go into those tissue, any fat that comes in or doesn't even come in, but any fat that we're using for fuel needs to be utilized for activity and that's where the caloric expenditure from fat comes in, so you're, basically saying you're General physiology, the Energy for that starts coming from fat and the energy that's coming in from carbohydrate needs to be simply stored, and so what you see is your respiratory quotient changes right, the rer is going is going off, and so in the exercise moment it shot way up for Carbohydrates and shot way down for fat as the compensatory response. It goes the other direction, because your body's saying we are low on carbohydrates, don't use them for fuel unless we absolutely have to right, so use them for storage, get our fuel from the fat side of the equation, and so what you're generally going to say, is Like, oh, I'm burning more fat just sitting around after things like that, and that's not even taking into the equation the epoch part which is like it's not actually as large as people think it is it's fairly small, but it is. It adds up sort of over time, so um does that explain a little bit

01:16:07 Muscle & Basal Metabolic Rate

Better about how you lose fat when you actually only burn carbs for exercise, you explained it beautifully. You talked about Epoch, the post-exercise oxygen consumption yeah, not being that significant in terms of energy utilization, even though, today we're talking about endurance and different forms of endurance, I do have to ask whether or not people consider the elevation in basal metabolism that occurs when there's More muscle around yeah, because muscle is such a metabolically demanding tissue um. You know, if is there a straightforward-ish equation? You know if one adds one pound of of lean muscle tissue to their body, even if it's distributed across multiple muscle groups. Does that equate to a caloric need of X number of calories per day, and is that because of the muscle, protein synthesis needs of that muscle or it's glycogen storage needs or both? If you don't have enough muscle, you start to have problems with fat loss. It'S difficult challenge: if you have enough muscle and you're just trying to get extremely large if your ffmi is 24 and you're 15 body fat, adding more muscles, not really going to play a lot in the equation and here's. Why muscle is more metabolically active at rest than fat, but fat is not inert, so fat is still going to burn a small number of calories muscle burns more, but it's not nearly what people think it is. I'M a muscle guy, I'm a muscle physiologist. I would love to get people to have more muscle for any excuse. I can it's not honest to say that, though you're talking about when I was in undergraduate, we would say numbers like 50 Cake House per day per pound is what you can look at right. So if you put on a pound of muscle spread across the body, your basal metabolic rate would go up by around 50 calories per day. I think that number is grossly exaggerated. It'S probably a tenth of that six to ten calories, maybe um it's hard to know exactly what that number is, but the more recent estimates are are something like that. So now, on one hand you could say: oh my gosh, that is not even meaningful the other hand. You could say that’s super meaningful. It just depends on time domain. You want to put that out right. So if you were to put on five pounds of muscle and your basal metabolic rate, went up 30 or 40 calories a day well over the course of a thousand days like that, actually adds up. So you you could slice this any way you want um. Now maybe that number somewhere in between, I don't really know it's not a field. I paid that much attention to candidly because it's not a metric kind of like epoch, um, where it's like. We used to really harp on it and now it's sort of like wow. Maybe we exaggerated that, like honestly just a bit but to me it doesn't change the equation much because if you don't have enough muscle as they describe, there are other consequences that are going to make fat loss hard, and so you need to have sufficient muscle. If the additional caloric expenditure is the carrot great, if it's something else, I don't really care, there's just enough evidence that you need to have it or I should say,

there's enough evidence that it will really help you in your path, um, maybe a few calories here. There is not really the thing, especially if you understand a normal food item. Anything you pick is going to be probably a couple of hundred calories. One bad food Choice a day. Well out, kick almost any amount of coverage. You got on adding muscle mass to you. So, like you're, really stepping over a dollar to pick up a dime. If you're worried about how many calories you're getting from adding muscle

01:19:40 InsideTracker

um fat loss is going to be about regulating that carbon intake above and beyond anything else.

I'd like to take a brief break to acknowledge our sponsor inside tracker inside tracker is a personalized nutrition platform that analyzes data from your blood and DNA to help you better understand your body and help you reach your health goals I've long been a believer in getting regular blood work done for the simple reason that many of the factors that impact your immediate and long-term health and well-being can only be analyzed from a quality blood test one issue with a lot of blood tests and DNA tests out there however is that you get information back about various levels of lipids and hormones and metabolic factors Etc but you don't know what to do with that information inside tracker makes knowing what to do with all that information exceedingly easy they have a personalized platform that lets you see what your specific numbers are of course but then also what sorts of Behavioral do's and don'ts what sorts of nutritional changes what sorts of supplementation would allow you to bring those levels into the ranges that are optimal for you if you'd like to try inside tracker you can visit insidetracker.com Huberman to get 20 off

01:20:43 Assessing Metabolic Flexibility, Blood Glucose, Carbohydrates

Better about how you lose fat when you actually only burn carbs for exercise, you explained it beautifully. You talked about Epoch, the post-exercise oxygen consumption yeah, not being that significant in terms of energy utilization, even though, today we're talking about endurance and different forms of endurance, I do have to ask whether or not people consider the elevation in basal metabolism that occurs when there's More muscle around yeah, because muscle is such a metabolically demanding tissue um. You know, if is there a

straightforward-ish equation? You know if one adds one pound of of lean muscle tissue to their body, even if it's distributed across multiple muscle groups. Does that equate to a caloric need of X number of calories per day, and is that because of the muscle, protein synthesis needs of that muscle or it's glycogen storage needs or both? If you don't have enough muscle, you start to have problems with fat loss. It'S difficult challenge: if you have enough muscle and you're just trying to get extremely large if your ffmi is 24 and you're 15 body fat, adding more muscles, not really going to play a lot in the equation and here's. Why muscle is more metabolically active at rest than fat, but fat is not inert, so fat is still going to burn a small number of calories muscle burns more, but it's not nearly what people think it is. I'M a muscle guy, I'm a muscle physiologist. I would love to get people to have more muscle for any excuse. I can it's not honest to say that, though you're talking about when I was in undergraduate, we would say numbers like 50 Cake House per day per pound is what you can look at right. So if you put on a pound of muscle spread across the body, your basal metabolic rate would go up by around 50 calories per day. I think that number is grossly exaggerated. It'S probably a tenth of that six to ten calories, maybe um it's hard to know exactly what that number is, but the more recent estimates are are something like that. So now, on one hand you could say: oh my gosh, that is not even meaningful the other hand. You could say that’s super meaningful. It just depends on time domain. You want to put that out right. So if you were to put on five pounds of muscle and your basal metabolic rate, went up 30 or 40 calories a day well over the course of a thousand days like that, actually adds up. So you you could slice this any way you want um. Now maybe that number somewhere in between, I don't really know it's not a field. I paid that much attention to candidly because it's not a metric kind of like epoch, um, where it's like. We used to really harp on it and now it's sort of like wow. Maybe we exaggerated that, like honestly just a bit but to me it doesn't change the equation much because if you don't have enough muscle as they describe, there are other consequences that are going to make fat loss hard, and so you need to have sufficient muscle. If the additional caloric expenditure is the carrot great, if it's something else, I don't really care, there's just enough evidence that you need to have it or I should say, there's enough evidence that it will really help you in your path, um, maybe a few calories here. There is not really the thing, especially if you understand a normal food item. Anything you pick is going to be probably a couple of hundred calories. One bad food Choice a day. Well out, kick almost any amount of coverage. You got on adding muscle mass to you. So, like you're, really stepping over a dollar to pick up a dime. If you're worried about how many calories you're getting from adding muscle

01:27:48 Caffeine, High-Carbohydrate Meals & Timing, Managing Daily Energy

Dosage and not you know, have to fall asleep afterwards. What is one way that people can enhance their utilization of carbohydrates uh for exercise? The reason I ask is, I think I fall into that category. Yep um. I do consume some complex carbohydrates and fruit post resistance, training, and that tends to be when I'm hungriest for them, but typically, unless I'm I've just done some resistance training, I keep most of my daytime meals, relatively low carbohydrate and then in the evening. I prefer slightly less protein and more carbohydrate because it has this effect of um sedating me a little bit yeah and I sleep well, and I know this runs against what everyone was taught, which is to not eat carbohydrates late in the day. But I like it because then I tend to wake up in the morning with at least as far as I can tell my glycogen stores, not necessarily topped off, but but certainly filled yep um and I'm able to train fasted in the morning and my favorite pre-workout Is consists of water and caffeine and electrolytes, and maybe some supplementation as well, but I love training fasted, so there's actually a number of things um, one little sneaky thing you threw in there is actually the use of caffeine. So that’s another sign if, if you have to have caffeine to do your fasted training, that’s generally another sign you're, not very good at using fuel. So I use caffeine prior to resistance training. Workouts generally, I don't need it for any kind of cardiovascular training, yeah and when I say that it doesn't mean it's bad, it's just like another clue. That’s like okay! You should be able to do this without having to have caffeine to execute it now using caffeine to get a better result is sort of different as an ergogenic aid um. We actually use a lot of high carbohydrate meals at the end of the day. A lot of the times for our athletes, who are cutting weight or trying to reduce weight. So it is a fantastic way to handle a lot of things and that idea that if you eat carbs late at night, that'll increase fat so, like that’s all, is so old and so well destroyed. Scientifically that that’s not a concern. Um, there's just so much data showing in fact there's so much. Data on like eating timing is, is uh generally poorly understood about when you can eat and what you can eat eating in the morning um versus eating at night, like a lot of what we've heard in there is stuff in. Maybe we just saved that for sort of another day, because we're going to get really far down that’s about our weekend yeah. But yes, I think our plan is to cover that in an episode on nutrition, um, okay, which is in this series the uh. The only thing that would add to it is, you know, would you hear about ingesting carbohydrate late at night? I should just say that uh, at least in my case, I'm eating the majority of my carbohydrate unless I trained yeah resistance trained early in the day and which guess I I post resistance, training um in the last meal of the day. But for me, that’s not really late at night that last meal is somewhere between 6 30 and 7 30 p.m. So it's three or so hours or something like that before we go to sleep around 10, 10, 30 or so yeah. So it's not. You know midnight uh, bowls of pasta. I'Ve done that too, but um, but typically it's not.

So I think that um people will be very interested, uh, myself included in how meal timing relates to all of this, but um yeah. Let'S so, how do you improve fat utilization? How do you improve carbohydrate organization? Let'S Hammer both out really quickly um enhancing fat uh utilization is as simple as doing a little bit of work in a either pre-fat ingested state. So anytime, you ingest a nutrient prior to training you're, going to bias towards that nutrient right, which is almost what we were talking about earlier. So if you want to guarantee you burn more fat, eat more fat prior to a workout, now you're not going to lose fat, but what you're, what you're effectively signaling is? We have an overabundance of this fuel preferentially Target this fuel. Now the downside is that may actually hinder your performance. That's typically only a concern for people at a very high level. Um fat is a slower fuel source. So if you're, relying more upon that your top end is going to come down a little bit, and so you wouldn't want to use that strategy prior to race. If it is a carbohydrate dependent race, all right and in fact we actually see long-term adaptations. That would suggest that so the enzymes responsible for carbohydrate metabolism will down, regulate and so you'll get worse at that. So not not a great strategy. There carbohydrate be the opposite right. So if you have carbohydrate prior to exercise you're going to bias more towards that, so a handful of things you can do if your total caloric intake is simply managed. That's going to take care of a lot of these problems, an appropriate eating strategy. So the types of food, the combinations of food, all those things are going to make your post carbohydrate ingestion bunk a lot of those things can go away. So there's a little bit of physiology. That has to be corrected, for so it's a little bit in one hand, you can go very deep here right, so the real answer of how we would do this is, if we see a scenario like that, we're going to do a whole set of analyzes we're Going to go full Labs right, probably extensive blood panel urine saliva, stool, even and we're going to figure out. Where is that glucose dysregulation coming from so a lot of people? Think like oh, it's a metabolism issue, it might be. It also might just be a flag that something else is happening in the body, so we're going to actually work backwards, a lot to try to figure out exactly why that's occurring. It may be as simple as oh you're eating a lot of your carbohydrates without any fiber or protein, and we know that that's important, because those will actually blunt the glycemic index like the rise in blood glucose. So it could be a simple thing of just like. Oh, your combination of food is doing it. It'S not the total amount um. It may be something again more endogenous to the actual system. Uh. It could be um a heart rate issue. It could be a breathing issue, there could be a number of things, so the way to get better at it is to Simply train it, and specificity is King here. So if you want to get better at managing your blood glucose throughout the day, so you're not feeling those things, it could be a fuel issue, but it could be a number of other things and it's just hard to go into all of them with within our Time constraint, so the Practical tool that I would say here is, if you

want to get better at managing energy throughout the day, make sure that number one your protein is stabilized, making sure number two you're ingesting your food in the right combinations, ideally with some Fiber And or some protein or both that alone will help stabilize a lot of the problems. Then you need to train at a high intensity. You want to get better at using carbohydrates as a fuel train at a higher intensity and have carbohydrates right before the workout. We'Ll do that a lot if um uh, if our, if we see folks who are I kind of walk you through the test of identifying if you're, not very good at using fat as a fuel, the tests for not being good at using carbohydrate is the fuel. Is both that eating test? I talked about as well as performance if you're a very, very, very slow starter. It'S just like really hard to get going. That generally indicates you might be in a situation where you're not very good, at using carbohydrates as a fuel. So we're going to practice that we're going to have a pre-carbohydrate, pre-exercise carbohydrate meal, then we're going to do higher intensity stuff, not the point of making you sick and digestive issues all that stuff. But we want to get better at using carbohydrates as a fuel faster. If you want to get better at doing the opposite, then you do that opposite starter, either again using the fat prior to the workout. Knowing your Peak Performance is going to go down a little bit but you're you're investing in adaptation right. So it's not about that. Workout it's about what's going to happen, six eight ten weeks from now investment is what you want to think about it or you could bring in some fasted training, and so I want to really make sure I clarify when we were talking about it earlier, I'm not At all against fasted training, it's not it works. It'S just isn't required for fat loss; it isn't required for fat adaptation. It is a great option, though, if you want um what I was hoping to do with that conversation, and maybe I didn't articulate that well, is to not restrict people but is to open you up and they'll say you have a lot of options if you like To do fasted, cardio amazing, it is great if you hate it, you don't have to you, can reach the same performance goals, the same physique goals without ever doing it. If you love long duration, steady state stuff, it is great if you hate it, there are other options, higher intensity stuff again, if we're just talking about fat loss, so I hope now that that’s a little clearer in terms of the same thing with nutrition, if you Like higher carb great, if you like, lower carb, these are all great. You have options and you don't have to fret so much over. Oh my gosh, I have to do this thing a certain way and I absolutely hate it. You don't have to

01:36:42 Cellular Energy (ATP) Production from Carbs; Lactate; Anerobic, Aerobic

Worry about it, hit those Concepts and you'll be fine. A few minutes ago you mentioned that. If we ingest a given macronutrient fat, then the body will preferentially use that fuel source

you ingest, carbohydrate, we'll use that fuel source. Is it always the case that the body uses the ingested macronutrient prior to using glycogen? I have to imagine it's using both I mean if I were to have some carbohydrate be before um doing any kind of training. The muscles still burn glycogen right or do they have some way to register the amount of circulating carbohydrate that would allow or available carbohydrate in the form of food stuffs uh. That would allow them to not tap into their own muscle, fiber stores with glycogen all right. So the way we derive energy for exercise or basic maintenance, a little bit about cellular physiology, so you've got a couple of organelle and structures that we need to pay attention to the first. One is the nucleus: let's Hold You DNA, the second one is the mitochondria, and then everything outside of that you've got all these other organelle that do a bunch of things like ribosomes, for protein synthesis, etc, etc. All right now, when you want to produce energy for exercise anytime, you hear the word anaerobic. You automatically understand. We are meaning without oxygen, all right great, that all happens in the cytoplasm. The cytoplasm is that space. That is not the mitochondria, not the nucleus. So it's the space in between everything else. This is like jelly-like substance that sounds there. So anaerobic metabolism happens there. Every single aerobic metabolic process happens in the mitochondria all right. Why is that important? If I go to create cellular energy and I need it the fastest possible I'm going to go for phospho creatine because it is stored directly in the cytoplasm, the stoichiometric is one to one there, which means for every mole of phosphocreatine. I burn. I can create one ATP, it's one to one. It is incredibly fast, but it is very limited because think about how much of that could I possibly store in the small size of the cell? That’s it if I need energy past that point now I'll start using muscle glycogen, because that is also stored in the cytoplasm. So it is right there. The Stoichiometry is not one to one. It'S a little bit higher, probably like four to one so for every molecule of glycogen. You burn you're, going to get something like four ish, some small number of ATP out of that which is great but again you're running into a storage problem. How much can I possibly store inside a muscle cell? It is very, very fast, much more effective than phosphor creatine, but so there, if I then want to metabolize any form of fat or if I want to complete the metabolization of carbohydrates, I have to start transferring into the mitochondria. Now I start getting whole hosts of ATP if you were to fully run through this thing which I'll talk about in a second, I'm called the TCA cycle or Krebs cycle you'll get now something like 28 or 30 or 35 kind of depending ATP per. So the energetic output is much higher okay. So here's exactly what happens, then I'm going to walk you through this in the form of carbohydrate and then I'll come backwards and go through fat. So remember carbohydrate. It is one carbon molecule that has been hydrated, so it is one to one so the actual chemistry here it is C H2O, one carbon, two H, one o glucose is a six carbon chain. So the chemistry here is C6 h12o6 six carbons, six Waters

very simple: that’s a carbohydrate all right! So you can imagine if you're watching on the video here, you'll you'll see my fingers going nuts I'll try to make sure. I explain it to you all. Just listening in an easy fashion, so you've got this chain of six carbons as in front of you and the very first step the metabolism. Is you snap that thing in half right, so you break into two separate three carbon chains all right now in doing that, you've got a little bit of energy because you broke that one Bond, but not a tremendous amount. This is called glycolysis, so lysis being the split and you know, glycoping, like you split glycogen up got a little bit of energy of them all right. You formed this three color carbon chain called pyruvate or pyruvic acid. Okay, there's differences there, but don't don't kill me General audience. Friends. All right! I got ta got ta give this communicate this to everybody. So you got a little bit of that now. You can't do much past that, besides rip one more carbon off of each of those three carbon chains, so I've got two three carbon chains. I'D have to be careful. How I do this with my finger, so I don't flip you off here in a second, but I burn one more off of each. I get a little bit of energy and now that little two carbon chain I have two two concrete chains. Those are called acetyl-coa. All right, amazing, I have now completed anaerobic glycolysis. I'Ve got really nothing left. I can do here. I made a little bit of ATP. Now wait a minute. I have now freed two carbons because remember I started with six and I splited them apart, but I didn't. I had two three carbon chains. I burned one. Each I've got two free floating carbons. I have to now do something with them. My body will not. Let me go through that part that last process, unless I've got a plan for that free Carbon, because I can't break it in half amazing. Here'S what's going to happen. If I have those three carbon molecules - and I don't have anywhere - I can put that carbon you're not going to go through that process, it's going to stop it you're, going to start building up pyruvate now, at the same time, you're breaking ATP for fuel, that’s called Atp hydrolysis right, you have water that comes in. You have a condensing and three phosphates. That’s why it's called ATP adenosine triphosphate one two: three! You break one of those phosphates off there. You go, there's your energy! So now you have a free floating, inorganic phosphate and an adenosine dye phosphate so two over there amazing that actually results because you use water for it results in a free-floating hydrogen ion. Okay, just have to trust me: hydrogen H2O, any idea what a free floating hydrogen is. Um, it's going to that’s acid yeah. It says I was going to say it's going to increase acidity! That’s what I said for anyone. That’s ever measured pH. What you're really measuring is the the amount of hydrogen potential hydrogen. That’s. What PH is Right. 100, there's two definitions of pH, but you get that’s one of the two. So is this. Are you going to tell me this is related to the the burn we're going to get close right, so I've got a bunch of free floating um. You'Ve got the phosphates, which are actually a problem, two probably more of a problem Than People realize and that hydrogen? What are you going to do with that hydrogen? Well,

one thing you can do is actually ship it over to pyruvate and bond it there. We have a special name for that. Little molecule when you have pyruvate and you have a hydrogen attached to it. You know what it's called: uh: hydrogen peroxide lactate lactate lactic acid. This is that whole system. Right again, I'm skipping some steps making a little bit of mistakes here intentionally folks just to make this assumed. So what happens when you start running a bunch of anaerobic glycolysis? You start seeing massive rises in lactate cool, not lactic, acid right right. That’s why we see associations between a lot of lactate and a lot of fatigue, but the lactate is actually not causing the fatigue. The lactate is actually sparing you from having a bunch of free-floating acid. It'S also can be, then used directly back in the muscle, because, as soon as you bring in enough oxygen - and you can take that hydrogen back off of it, you've now turned it right back into pyruvate. You can run it through this whole cycle as fuel that I'm about to do. You can actually actually ship it out of the exercising muscle and ship it into a non-exercising muscle and then go backwards and make glucose what actually liberates hydrogen from from lactate. Well, you like chemically yeah, so what what liberates uh? What well? What are the stimuli that can take hydrogen off the pyruvate yeah, oh yeah, and and then, in other words, to reduce lactate and free up that hydrogen oxygen availability. So in fact, one of the major places that you ship hydrogen to or one of the major places that you ship likely to is your heart, because it's what we call like the ultimate slow touch, fiber and it is - has a ton of freely available mitochondria which Have a ton of access to oxygen, so it can actually then go to it form water. The H2O can be used to form water, and now we have a place to store the hydrogen, got it right cool. So, as a result of anaerobic glycolysis, we have made a little bit of ATP. We'Ve created a lot of waste and we don't have anywhere to to go with these end products. So when you do anything of a higher intensity - and it says I need energy fast you're - going to go to this system - first right right, past ATP, because it is the fastest place to get energy, but you're not going to get much of it and you've got To deal with the waste products boom right back to the beginning of our conversation, endurance is about two things: energy production and waste management and we're right we're fatigue buffering this. Is it right? How well can you handle the elevations in hydrogen right drop in PH and how and then what are you going to do with these products? If you want to fully metabolize a carbohydrate, you then have to take some do something with those pyruvates or those acetyl coase. What you're going to do if oxygen is available, you will take those things and ship them into the mitochondria. They have to go through some cell walls and some other things like that, but they're going to get inside there once they're in there that two carbon acetyl-coa runs through this entire cycle that we call the Krebs cycle. That’s this really interesting place. That’s where B6 and nmn people are like. That’s where that whole stuff starts to kick in all your B. Vitamins basically run that entire circle and you're going to start off

the top. You have a bunch of fun stuff going on, but as a part of that Circle, you're going to pull off some some of the hydrogen ions you're going to send these to What's called the electron transport chain. That's where you're going to get a ton of ATP out of and as a result about halfway through the turn you're going to pull off one carbon and about halfway through the other, almost the other way to the Finish, you're going to pull off the second carbon. So you're going to take the second acetyl-coa run that entire thing same through as well, and so what we did is we started off with a six carbon glucose chain. We split it in half. We call those pyruvate made a little bit of energy because we broke that one Bond of those two carbons that are in the middle cool those two three carbon molecules. We pulled one carbon off of each we brought in sorry, we moved those into the mitochondria. We brought one off. We took a breath brought in some oxygen bonded that Brett took out two CO2 exhales. We ran the acetyl-coa through the Krebs cycle. One two carbons per turn coming out of CO2, so we had six carbons total as we started and we exited with zero carbons. Now we have fully metabolized a molecule of carbohydrate that required an anaerobic start and an aerobic finish. If you don't have a lot of mitochondria large mitochondria high functioning mitochondria you're, going to limit your anaerobic performance because you're going to get they're going to run that door full very, very quickly, you can't go past it because hydrogen will build up way too fast and One of the things that we know is both temperature and pH, run enzyme function, so they're going to stop, you won't even be able to run through, in fact that ATP hydrolysis phase, even if I gave you a whole infinite supply of ATP. If I put enough acid in there, it would stop working because the ATP Ace enzyme needed to split it won't be able to run in a highly acidic environment or a hot environment yeah at some point, perhaps today, perhaps in a future discussion, but still not too Far from now, we could talk about the role of temperature uh in the uh in pyruvate, from in terms of its regulation muscle contraction, but I want to make sure I understood something correctly. You mentioned these these uh two parallel fuel systems right, one is essentially anaerobic right and the other is aerobic. You said that if we can't pull enough um, if we can't break enough bonds, then we limit our anaerobic capacity correct. I would have thought given that uh, the mitochondria or the site for essentially for aerobic metabolism, that we would be limiting our aerobic capacity as well um. Perhaps you could just clarify for me how these two things are divided or is there not a clean division? Is it not an either? No, in fact again, I think it's better to think of these things, rather as two separate parallel things as one big cycle they're one gear. Turning the next being compromised in one will compromise the other that I should say reminds me of what you said earlier, which is this the bicycle gear analogy that works uh great. So if you, if you short circuit one, basically that the chain can't move, that's yeah, fantastic, okay, so um, so indeed they they are running in parallel, but they are um, interdependent, yeah, well,

they're, actually not even running in parallel, because they're actually funneling to the same Endpoint right, which is like, if you're going to come from the anaerobic glycolysis route or you're, going to come from the fat route which I'll talk about in a second they're, both going to be limited in the mitochondria. So when that thing's full it doesn't matter, you can't run either system right. So it is more of like a again if you're running the bike gears it doesn't really matter if the back one's larger or smaller, because if either one is limited. Your toast, because they're running on the same system,

01:50:45 Lactate, Energy Production Buffer

You can you, can you can sneak a little bit here and there, but but not much. You also really nicely highlighted how lactate this thing that we think of as a a limiting factor like the burn it gets in the way and it's the thing we need to stop and buffer and all all sorts of things sure it's actually really a fuel. It'S a tremendously effective fuel. It is a strongly preferred fuel. Actually, the is this interesting. This is a very classic case of Association, um correlation versus causation right. So the original actually like, there's a really cool history on lactate, but it was originally found uh. I think in Germany um part of my history there um somewhere in Europe in hunted Stags, so one of the things is they sort of realized is like. If we, if we, if we harvested a stag in a rest estate, when it didn't know, we were there versus if we chased it and it was ran down that these lactate concentrations were significantly higher in in the latter situation. Therefore, lactate started immediately getting this association between High fatigue points and it is easy to measure if you were to do any sort of lactate test. Any sort of metabolic test you will see as fatigue increases. Lactate will also increase the Assumption. There was then, oh, my gosh is the cause. Now we know like again: it's not the thing, it's in large part, trying to buffer the negative consequences of ATP, hydrolysis and and some other things. So it is certainly playing a part in that role, but it is not the core driver. It'S also why you don't need to worry about doing things to quote unquote: um reduce lactate in the muscle after exercise or to clear lactate or any of those things. You may still want to do those activities, but not for that reason. Lactate'S fine you're actually going to use it in again the neighboring exercise, muscle fibers in the same muscle, another muscle you can send it actually to the to the liver and it can actually go through gluconeogenesis and it can actually replenish liver. Glycogen. Just does that feel sore. Sorry, you sound harder any number of sources. You can also just kind of put it in circulation. Put a back in the muscle and once enough oxygen is there, you can just kick it right back into either glucose or glycogen. It'S totally fine, so it is obviously clear, though, once that number gets very, very high. Other

things are going to be happening, they're going to be causing a lot of hurt, and this is your managing waste right. It is really an issue of managing. What am I going to do with all this extra carbon? What am I going to do with all this extra inorganic phosphate and some other nasty

01:53:14 Fuel Sources & Exercise; Mitochondria, Oxygen Availability & Lactate

Byproducts, but that’s the thing you have to deal with I'd love for you to teach me how different ratios of fuel sources are used depending on how long I happen to be exercising. For example, if I do a very short bout of exercise - yep, typically that’s correlated with a higher intensity output - I mean, I suppose I could jog for one minute, but here I'm thinking about sprinting for one minute or less which fuels are used. Is that mainly driven by fat stores by carbohydrate stores? Is it driven by dietary fat preferentially or carbohydrate that I've ingested, if indeed I've ingested those or protein for that matter, and then, as we transition to exercise that goes a little bit longer? You know anywhere from you know three to five minutes: how do those ratios change and as we transition to longer duration, what most people think of as endurance exercise but long duration, output of you know 20 minutes or more leading all the way up to a full Marathon, how does that change the ratio of fuel sources that are used and I'd be particularly interested in distinguishing between carbohydrate fat and protein, that’s ingested so coming from food sources or carbohydrate fat and protein that are coming from Storage sites within the body? Okay, great. Let'S start at zero seconds and run all the way through Marathon and we'll we'll flag the distinctions where they start changing as soon as you want to create muscle, contraction and power, the very first source of energy is phosphoid. Creatine, that’s going to power you for zero, to maybe say eight to Fifteen twenty seconds of maximal exertion and that’s in coming from the muscle fibers themselves, yeah that is actually stored in the What's called the cytoplasm. So this is a little area of space in the muscle fiber, that’s sort of like in this jelly-like substance and it's nice, because one molecule of phosphoid creatine gives you one molecule of ATP. So it's not a big energy output, but it's very fast because it is stored right there in the local, exercising muscle right now. If you need energy past that point say you know 10 or 15 seconds up to maybe a couple of minutes. This is now you're going to have to transition because you're going to burn through that phospho-creatine, it's going to be out you're going to have to move to now carbohydrate metabolism. This is what we call anaerobic glycolysis. So there's two phases of glycolysis now glycolysis itself means glucose burning all right, so this means we're using carbohydrate as a fuel source. So initially, when we start off this

Cascade, which is going to take us again for a couple of minutes, carbohydrate utilization comes first from the exercising muscle, so it's very similar to phosphocreatine that way. If you start running low on it, you can actually start pulling blood glucose and if blood glucose gets low, you'll have to start getting glycogen from the liver to keep that up and we've sort of covered that conversation all right. So a little bit of chemistry here, just give me a little bit of room here so now remember a carbohydrate is a carbon molecule that has been hydrated, so one carbon attached to one water and remember water is H2O most of the time when we're talking about Glucose, it is in the six carbon chain, so six carbons attached to six water molecules all right great. When I go to split this up through anaerobic glycolysis, it works a little bit like this, so you've got this six carbon chain. The first step is to snap that thing in half you're going to make two three carbon chains. Now we broke one Bond right there, so we got a little bit of energy, but not a tremendous amount at the end of anaerobic glycolysis you're going to net something like three or four ATP, so more than you get from the phosphate quadruple, but still not very Much there's another major downside. That’s coming in a second to this system. The upside is it's fast now. What actually one adaptation we get to? Training in this style is you'll increase your ability to store glycogen in your muscle, which is great right. We can actually biopsy you and measure the amount that you store in a training. Adaptation is awesome, so you're able to sustain this system longer so perhaps 90 seconds into your interval training. You hit a fatigue point, and now you maybe can extend that to 100 or 115 seconds, simply because you're storing more glycogen in the muscle before we have to and then go into the blood and get up in the form of glucose. So that’s great! So we've got this six carbon molecule and we split this in half. We got that little bit of ATP and now we're in this little tricky position, because this three carbon molecule is what we call pyruvate pyruvic acid and again chemistry. Folks, I'm skipping some steps. I'M going to intentionally make some mistakes here. I'M making sure the entire world listening regardless of where they come in, can follow me here. Okay, so don't burn me on the details. Right you've got this pyruvate. The problem is, you can no longer do anything with that? Glycolysis is over, you've got to make a choice right in order to make something out of those three carbon molecules. You'Ve got to ship them to the mitochondria, as we said, that is the only place of aerobic metabolism right. We cannot do aerobic metabolism anywhere else until we enter the mitochondria so anytime we cross that barrier. We know we've automatically switched from anaerobic to aerobic. Well, here's the problem. If you were to take one more carbon off that three carbon pyruvate, you have to now do something with that carbon waste. Okay. So before, when we split the six carbon chain, we didn't actually leave any carbons free floating. We just split a two molecule in half when we go to split from pyruvate and make it into this two carbon molecule called acetyl-coa or seal COA. Now

we've got a free-floating carbon. We have to have a strategy for that, because that's going to increase the acidity level, any enzyme in our body that works to create fuel is very pH sensitive right. So if this thing, if pH, gets off either high or low, these enzymes can't work and that's really really important, because even if I were to give you a direct injection of ATP, remember that's that energy currency, that's the only way we can actually form energy. I guess remember to clarify anytime we're using phosphoid, creatine or glucose or fat which we'll get to a second we're, not actually getting energy for exercise by breaking those down or getting energy that we can use to then make ATP. We break that ATP down. That's! What'S actually powering muscle contraction um, you can go back to our previous episode where we'll walk you through the detail of the muscle contraction, but that's what we're after okay. So in the case of pyruvate, if we split that off, we have got to deal with that and the only way in the best way we can deal with that is oxygen. Remember we're going to breathe in O2. That O2 is going to combine with that free-floating carbon makes CO2 we're going to Exhale. That thing out, that's our Waste Management strategy, but that has to happen in the mitochondria. Remember if we're using oxygen, it has to be in the mitochondria. So if we have the ability to ship pyruvate into the mitochondria or golden, but what happens if we don't? Why do we not well if we don't have enough mitochondria or mitochondria are too small or they're too far away or we don't have sufficient oxygen availability? Why don't we have sufficient oxygen availability because we created the pyruvate too fast and the demand in the mitochondria is exceeded by the buildup of pyruvate, and so now we're having this giant backlog, and this thing fills up fast. We have a couple of strategies here. Well, when you're going through ATP and you're splitting, it's called hcp hydrolysis in of doing that. Remember ATP is a adenosine molecule and then the T part is triphosphate one, two three, which means you have three phosphates attached to the end. When you break that phosphate off. That's where you get your energy, so now you have an inorganic phosphate and an ADP. It doesn't diphosphate two that process requires water. It'S called hydrolysis as a result of that you then have a free floating hydrogen and, as you well know, that is acid right. That's potential hydrogen, that's what that means, and so you've increased the acidity in the muscle by breaking up all this ATP, and so oh we're building up acid. We have building up pyruvate, we don't have nowhere to go with it and we can't cleave off a carbon, because now we're just going to exacerbate the acid increase. So what we can do is we can take those hydrogens that we're building up and store them on the pyruvate, a pyruvate, that's holding an extra acid has a special name, and we call that lactate all right. So that's why we see this buildup of lactase. So one of the downsides of anaerobic glycolysis is an incredibly High rate of waste production. Now lactate is not the cause of fatigue. In fact, if you think a little bit more carefully about what I just said, it's actually stopping you, it's what we call a acid

buffer. You can actually use it for a bunch of other things. You can ship it to a neighboring muscle fiber. In the same muscle, that's not working, you can ship it to the liver. You can ship it to the heart and a bunch of other places, and then you can actually just work backwards. So if you ship it to, for example, the heart and it's got a bunch of mitochondria that are free, you can bring in the oxygen attach it to that hydrogen, make water and now you're right back to pyruvate. You put two pyruvate back together and now you just make glucose, so you can actually store it in the liver. This is a process called gluconeogenesis through this fancy thing called the Corey cycle.

02:02:50 Lactate for Exercise & Cognitive Performance

Which is what the the proper cycle here is, so you can use it as a very potent fuel source. In fact, a lactate is a tremendously valuable fuel source, I'm not like for exercise, but for cognition and a bunch of other things, so lactase. In fact, this is why um, if you've seen the research about pre-exam testing, exercise, uh you'll see a noticeable increase in exam scores. If you do a 20 minute about of exercise prior to taking the exam - and it's largely in part, probably because of things like elevations and lactate, how intense of exercise uh would be most beneficial? I don't know that exact answer. I just know that, generally, any form of exercise is good, but if you were to reach a reasonably high heart rate, you're - probably going to see in fact there's an acute and chronic adaptation here. So Folks at exercise have better memory, memory, retention, scores and exams Etc. But then also doing it prior to that exam make sure you recovered and rested back down the street, but you'll generally perform better previous guests on the Huberman Lab podcast who's, the who's, a psychology, professor and neuroscientist, and also dean of College of Arts and Sciences at New York, University, NYU, Wendy Suzuki, is religious about daily morning exercise yeah, specifically for this purpose of enhancing learning and memory, and has a lot of really beautiful data. I consider one of the real Pioneers in this space um. So if people want to learn more, they can look to that episode or Wendy's work. We can provide a link to a couple of the papers, but this is fantastic in that it's incredibly clear. I think, for the first time, I'm understanding what what lactate is really doing: yeah um and it's dispelling a lot of myths that I think I and a lot of other people.

02:04:33 Energy Production, Waste Management & Endurance Exercise; Insulin

Arrive to the discussion about lactate, with what happens when the bout of exercise extends

longer amazing. So if we want to continue past that point, we have to have some sort of strategy to get through it right we're stuck we're out of gas. We have to then ship it to the mitochondria and now we're going to enter what's called aerobic glycolysis, and this is going to take us anywhere from again say that 90 seconds of all that work up to really 20 30 minutes. In fact, it really will take us to unlimited if you look at a highly competitive marathon runner, even those that are running say your two hour marathon. Those folks are burning up to 80 carbohydrate. It is a it. It is not a fat burning thing and the reason is fat metabolism is way too slow. It provides a lot of energy, but it is incredibly slow if you're trying to run a four and a half or so minute mile repeated 26 times, you have to be moving fast. Are they ingesting carbohydrate as a fuel source during the race unless you're on the team, you don't know, they won't really tell you. These are sort of Trade Secrets um. It would be, I would say, fairly rare, to not have something right. There'S a bunch of different strategies: if you're going to go really long like some of these um like cycling, where the races will be several hours, then you actually might go to some fat as fuel sources. I I know a lot of cyclists are using ketones and things like that now, but traditionally most endurance folks are going to buy us heavily towards carbohydrate um. Now, in one respect, you're not going to run out of carbohydrates until you're many hours in these folks are a unique case, but the average individual who's doing an hour hour and a half cardio, even you're, not going to be limited by your carbohydrate stores. You'Re going to be just fine, you're going to be limited by some other things, which will maybe sort of break down here in a second but you're going to be fine there. A lot of those folks will take carbohydrate they'll have very specific intervals. You want to you do want to be careful, though, of ingesting too many fast carbohydrates prior to your exercise, spout um. We actually have this little thing. That’s called the insulin glucose double whammy and what that means is when you ingest carbohydrates, immediately your blood glucose goes up and that’s depending on the type of carbohydrate and things like that. Well, the same thing happens with exercise, and so what happens is insulin wants to start pulling glucose out of the blood? At the same time, muscle wants to start pulling glucose out of the blood, and so we have this giant bolus of carbohydrate come in and then all of a sudden, our blood sugar crashes. And so, if you're going to be doing so, your your first half marathon or something like that and you're in those giant Corrals where there's like you know, 100 people waiting to go and you're standing there for 45 minutes, you may or may not want to slug Down like three or four bananas in a bagel and and honey, and things like you probably don't need that now, not everyone experiences this double whammy, but it has been shown in literature to happen to some people. So you want to just be a little bit careful um, an easy way to combat. That is just practice exactly what you're going to do in your race in your training. That’s, like the simplest advice ever but you'd be stunned. How many people

do things uh during the race that they've actually never done in training? I suggest people do exactly what you describe also for any kind of cognitive testing. Of course, before a big exam is not the time to discover whether or not you can handle twice as much espresso or take a nootropic for the first time or no uh or change anything I mean if if indeed the the score on that exam is, is Meaningful to you, you keep keep things regular. So to recap, what we've done here is we started off in the cytoplasm with this glucose molecule. That is six carbons. We took that thing. We split it in half. We call that thing anaerobic glycolysis. We made a little bit of energy, but not much. We take those three carbon molecules. We ship them into the mitochondria. We take each one of those we clear off one carbon, each, those carbons we take a breath in we attach them to oxygen. We exhale them get rid of that energy. We are now fully into aerobic glycolysis each one of those two carbon molecules. We run through the Krebs cycle each round the Krebs cycle Burns one two carbons, so we go one two one. Two and now we've gone from six carbon molecule all the way down to zero. We used the hydrogens that we pulled off of that Krebs cycle run to go to the electron transport chain. From there we made a whole bunch of ATP, and so we have now fully metabolized one molecule of carbohydrate and the end product of all of it is simply ATP water and CO2 beautiful and leads me to the conclusion that most everything is really about utilization of Carbons and exhaling CO2 is that how I should think about bookending what you just described? This is why we started off the conversation with the circle of life. This is really a carbon game. This is why we call Chemistry with carbon organic chemistry right. That’s what this whole thing is about, any living being has to run through metabolism. It'S all a carbon game, any living being has to use ATP. This is all just a big fancy game of how do I make ATP and handle the waste? Remember. Endurance is all about Waste Management fatigue, resistance, the same thing and energy production, we're playing a game here, the whole game bring in energy, use it mitigate waste products. So when thinking about aerobic exercise or long duration exercise in this case anything longer than five minutes for that matter, five minutes all the way up to an ultra marathon, the breathing associated with endurance exercise, the heart beating, which of course, is associated with the breathing and Vice versa, it's really all about bringing oxygen into the system that then allows those carbons to be used and within the mitochondria specifically, and then carbon dioxide to be exhaled as we work through the carbons of the sort of beads on a string. Is that right? Unless you're moving incredibly fast for a very long time and we're talking probably north of 90 minutes, endurance is really not a game of making sure I have enough fuel, it is simply managing the waste production and that’s exactly what you described. You need to bring in the oxygen so you can handle the carbon that’s building up as a result of both the anaerobic, anaerobic glycolysis. That’s our game here. If we start talking about endurance events longer

than that now we do have to start worrying about running out of muscle, glycogen running out of liver, glycogen, Etc, or if we are at that two hour mark or so, and we're moving very, very, very fast, but anything South of that is just managing carbon buildup and we do that best through oxygen utilization or getting more efficient, having a higher capacity for our anaerobic side. So we can do that by having either more glycogen in our muscle so that lasts longer or building better asset. Buffering systems and there's a whole line of supplementation that are specifically acid buffers there's a whole line of training, there's a whole line of breathing to manage this that so we have a lot of strategies where we can maximize endurance. All we have to do is go back to the earlier part of our talk, which is figure out. What'S the actual, limiting step and then train according to that, or do your strategy, your nutrition, your supplementation that defeats that limiting factor for an example if you're trying to maximize your performance in this 20 second maximal burst and your strategy for that was to make sure Your muscle glycogen is saturated, it's probably not going to help a ton because you're not going to be limited by total fuel you're going to be limited by your ability to buffer acid. However, storing more glycogen in your muscle in preparation for a marathon is a tremendously effective strategy, because that will become a limiting factor, so what we can do actually, next, if you'd like is, we can just walk through these and look at the individual limitations.

02:12:49 Protein & Fat Utilization for Energy; Exercise & Fat Loss

Where the failure Point happens and that effectively will outline your strategy for improving them, so you taught us about carbohydrate utilization as a fuel source. What about fat and what about protein great I'll start with protein, because it's easy it is generally at best going to represent 10 percent of your energy output. Now that will grow over time in terms of if you did a several hour lot of exercise when you started doing it, you might be using five percent of your energy from protein and then in that micro to 10 or so, and that happens because you start Running low on muscle, glycogen, you start running low on liver glycogen. You start then, having to pull in energy from another place so like as those numbers go down, you'll see an increased uptick of energy from fat as well as protein. Having said that, it's not a tremendous fuel source, it is only aerobic, so it has to be oxidized. Those are the same thing when I say oxidized, you use oxygen to burn something to make a fuel um, so it's not a significant contributor to energy. In that regard, and unless you're talking ultramarathons are longer - and it is also not something that can enhance performance, and so we don't really need to talk much more about it than that in terms of fat as a fuel source. Now here's the

fundamental difference while carbohydrate starts anaerobically and finishes aerobically in the mitochondria you're, using mostly the carbohydrate in the exercising muscle tissue. Eventually, you can pull from blood and then you can pull from the liver with fat. You have a tiny amount stored in the muscle, intramuscular triglycerides, but the overwhelming majority of fuel you get from fat comes systemically, and so now we have a fundamental difference. We actually literally have a Time problem. I can get energy from carbohydrates faster because it is directly there if I go to pull it from fat. I'Ve got to pull it from the rest of the body, which is why somebody who loses fat loses it from their entire body, despite the fact that they may be only exercising a couple of parts, so think about a runner. Someone who lost a lot of fat or running you don't see them just lose fat in their legs. It comes from their face and their neck and everywhere. Why? Because what you're going to do is pull fat from the entire system, you're going to break it down through a process called lipolysis, which means you break it down from the stored form. You put it in the blood as that glycerol backbone, which is that three carbon backbone in the individual fatty acids it's going to float through the blood. There'S a seven step system here, but we'll skip it. For now it's going to have to get then uptaken into the muscle in the muscle. Then it has to get taken up and run into the mitochondria now that backbone, that three carbon glycerol backbone is actually going to function almost exactly like the three carbon pyruvate. Just get it into the mitochondria cleave off one carbon run it as acetylch exact same thing: super easy to metabolize small enough to go through the mitochondrial membrane. The fatty acid chains become a problem, so if you have a chain that’s longer than or eight or so carbons, it has to actually go through a special transporter on the cell wall to get in and that’s going to be limited by a thing called carnitine and You'Re, probably familiar with that, as a supplement you may have talked about it, there's a lot of places that make it that’s going to be a limiting factor if it is a smaller, what we call a short chain or even a medium chain triglyceride, which a lot Of folks have heard of MCT, that’s what we're talking about that can actually go directly through because it's small enough to pass through, and you can use it immediately as an energy source in either case. The way that you finally metabolize a fatty acid is a process where you would go through and cut off two carbons at a time. Why would you cut off too, because you're trying to make that two carbon acetyl COA, so you can run through that Krebs cycle? Again, because you're cutting off two carbons at a time we have a special name for that oxidation process. It'S called beta oxidation. That’s exactly why we call it beta oxidation, two carbons in you, cut it off to make that acetalkoa. So you cannotice the oxidation pathway. The electron transport pathway is identical, whether you're talking about the carbohydrates or the fat. In fact, it doesn't even matter more to our point if we're talking about simply fat loss. It really just is about running that electron transport chain, whether it came from a carbohydrate or original

Source or a fat original Source. It ends up in the mitochondria as basically the exact same thing. It then ends the end of metabolism. As the same thing remember, the final endpoint of carbohydrate metabolism is water, ATP and CO2. Do you want to guess the final endpoint of fat metabolism, water, ATP and CO2, so practical applications here? If you want to maximize fat loss, what type of training is best? It really doesn't matter if you enjoy longer steady state stuff, fantastic. If you enjoy intervals amazing, if you would like to do a combination, that’s my personal preference, that’s great too! You have a ton of options pick. What you think is a combination of challenging. Not all exercise should be easy, but you will actually enjoy someone or you're willing to accept and anything that you absolutely hate. Don'T do. It sometimes is very, very, very difficult to do high intensity training. You have to really be interested in doing it. If not, it ends up turning into like moderate intensity training, you sort of just check the box and it doesn't work that well, if you're just checking the box. So if you're, like man mentally, I don't have it in me today to get to a high heart rate and throw up and all that stuff cool. But you can just do some moderate, steady state stuff. Well, that’s a win great. If you're, like, oh my gosh more than 10 straight minutes and I'm so bored and you're, all maybe you're, also like I don't have 45 minutes, I got to get this done in eight minutes. Great go. Do some high, intense intervals? Either option will be equally effective, as you mentioned earlier. Exercise is useful for aesthetic changes functionality and for longevity, but when thinking about exercise specifically for fat loss, I do have to ask this question. I often hear from people that they prefer one type of exercise versus another for sake of fat loss, because certain forms of exercise make them very hungry. I'M wondering whether or not there's any relationship between the intensity or type of exercise and the hunger stimulus. Now I don't have this problem because basically everything makes me hungry um and yet I'm also okay fasting for part of the day. Yeah I'm one of those pseudo-intermittent fasters talk about what I mean by that I just happen to eat between 11 A.M and 8 PM. Naturally, I'm not religious about it, but um, but I don't do it for any other reason, except that that tends to be when I'm hungry and I exercise outside of that um in the morning. Typically, in any case, is there a way that people can determine what type of exercise might be better or worse for them, based on its appetite, stimulating or inhibiting effects, because I also hear that you know some people will go for a long run and then they Are quote unquote not hungry for several hours afterwards does that have anything to do with which fuels are being utilized during different forms of exercise? That’s actually a really good question. I don't know the the mechanisms that can explain that answer. What I can tell you is you hear the same comment for physical activity, in other words, people say man. If I do this type of training, then I just am exhausted and I lay around the rest of the day. So my total caloric expenditure is actually compromised. As an aggregate, because I'm down um, the data would suggest in general

that doesn't happen so most of the time we don't see a reduction in physical activity um with either high intensity or steady state training. In fact, you generally see equal, if not increased. What'S called need, so it's the non-exercising part of your day, in addition to the basal metabolic rate, so physical activity, wise, you don't send to be prop now. Hunger is a little bit of a different thing. The answer here is, I don't think we have time to actually do justice on this, so perhaps best to not get into this one yeah. Why don't we punt this down the

02:21:20 Protein as Fuel Source, Fire Analogy

Road to our discussion about nutrition, specifically and and weave back to it, so we'll earmark it for that um. Meanwhile, it sounds like if one is thinking purely in terms of uh burning calories, yep and getting the health benefits of exercise to create a caloric deficit to create fat loss. It doesn't matter whether or not they burn those calories using a form of exercise that relies predominantly on carbohydrate fat or protein correct. It'S not that it doesn't matter it's that either one will work, because when we say things like that, it's it doesn't mean they're actually identical. There are some slight differences, and maybe those differences are important for some people, and not others ought to say, is either one is a viable strategy, great what about protein as a fuel as an actual feel so here let me give you an analogy. Imagine that you are, you were with me a few weeks ago in southern Montana and we're out um in the wilderness for a week, okay and it's cold out there and you needed to make a fire uh and if I said look you can pick any of These things there are so there's some wood over there we brought some newspaper and then we brought a match and we need to create a fire, we're going to use that fire to energy and heat up. Okay, I said great the very first place. You would probably start to make that fire is the match. You like the match in any match: hey it's going to light immediately, but it's probably going to last 5 to 20 seconds. I don't know before it burns out. That’s fossil creatine, real, fast, real Burns Out. If you were smart, you would take that match and then light the newspaper on fire right now. If you were to burn a whole newspaper, it is more energy, then you get to the match, but you still, you know I don't know. What'S going to take a few minutes, some number of minutes before an entire 65 burns up - five, I don't know right - depends on then yeah, which type of newspaper it is. I guess right, amazing, that’s carbohydrate! Right! If you were really smart, you would use that to then light a piece of wood on fire and a wood. If you've been in the wilderness, it could last hours days. It'S really quite unlimited. Your phospho, creatine storage is very limited. Small glycogen is a lot higher because you can store it in muscle. You can store it in other places, so you have more, but not a lot. Fat is unlimited. The

average person, if you're around, say 70 kilos up 170 pounds or so and you're moderately lean. Maybe 15 body fat, nothing crazy! You probably have enough stored fat to create enough energy to survive for more than 30 days right. This would literally be if you ingested, zero calories. You have enough fuel in your stored fat to keep you alive for certainly 30 days. You wouldn't feel good and all those things but energetically, basically fat will never ever be your limiting factor to Performance. So when we start talking about well what limits my performance in these areas, you can just wipe fat off the list. It will never be your limiting factor to any type of endurance performance. You simply have way too much. The only problem with fat is is just too slow. I'Ve got to mobilize it. I'Ve got to get in the blood move it that whole thing too slow. So if I want to go faster, I will never be able to fully utilize fat, which is why we talked about earlier you'll, never see a situation in which somebody is a hundred percent burning fat as a fuel and no percent carbohydrate. It'S always going to be too slow. Highest you'll get maybe 70 so percent protein in this equation is none of that. Now you may notice. How do you make paper? What'S fibrous you combine with water that you it gets pressed. It gets compressed. Yeah yeah, it's made from wood. How do you make a match? It'S made from wood? What'S carbohydrate a chain of carbon? What'S fat, a chain of carbon, these are similar molecules. Right they're meant to give you pros and cons, it's very difficult to just light a log on fire without a lot of work, you'd have to burn, burn, burn, burn burn, so these are complementary systems that are really close to the same thing. Protein is none of those things. Protein is more like a piece of metal. So if you were out in the woods with me and we were trying to make a fire and you're like hey, look, I found some old uh railroad over there. Let'S throw that on there, I would probably look at you like crazy. Now, technically, can you melt metal sure, but you're going to burn a lot of energy to try to get a little bit back out of the metal and now you've also cost yourself. A very very valuable structure, so protein is a fuel source for exercise or metabolism. It'S just an incredibly poor choice. Your body will do it again, maybe five to ten percent, but you now you're burning a very valuable Supply in a situation in which you don't know where there's ever going to be anymore. Remember protein is fairly transient. It'S you're, not very good, at storing it. You can store a ton of carbohydrate and an unlimited, literally amount of fat, so you just really need to disregard thinking about protein as a fuel source. Your body does not want to do it, you're, not good at it. You can go through a process of gluconeogenesis from protein. Make glucose from. It is just very poor, you're not going to get much out of the exchange and you've burned your supply of metal, which is going to be very

02:26:39 Low-Carbohydrate Diet & Performance

Difficult, it's a very high commodity in the woods or the Wilderness, to have something like metal for people that consume very low carbohydrate or zero carbohydrate diets. Are they pulling more energy from muscle so which I imagine is a conversion of amino acids into ready carbon chains? Yeah I mean in this particular case once you've reached um a certain level of adaptation. You'Ve just gotten extremely good at generating glucose from other Fashions right, so you can bias heavily towards fat adaptation. The downside is, and we've seen this born in literature you're going to perform slower. So if you don't care about maximizing performance, especially over something where it is a maximal effort for a few minutes or something then maybe you're not concerned, and that’s absolutely great, especially for people just don't exercise, then hey geez, very little concern here. But if you're interested in your performance and you're wondering why you're just like slugging it down well, what you've done is you've down regulated the ability, literally the enzymes responsible, for that entire anaerobic glycolysis portion. They get down regulated, which means there's not as much around anymore, and so you get really bad and slow at using carbohydrates as a fuel source. So it's a very poor strategy for people on an anaerobic based sport or who, like that type of activity. Again, if you don't care, no problem, if you don't exercise at all, then you really have no problem there, which is actually why a high fat, low, carbohydrate nutrition strategy for people who don't do much physical activity is probably like very well, it's very effective. It is a really good strategy for weight management for energy stabilization throughout the day, and the research would very much support that. In my observation I would agree: I've tried low, carbohydrate diets of severely limiting or completely eliminating carbohydrate and after about two or three days, I feel pretty lousy, but mostly because I want to train very intensely in the gym. In addition to doing longer runs, I tend to do all of those things across the week yeah, but I've also observed and in fact know several people that love the very low carbohydrate AKA ketogenic type diet, they're, not doing ketogenic diets for mental health reasons per se. But indeed, those people tend to do very limited exercise or they tend to do a lot of long endurance but low intensity, long endurance. These are the I walk to get my exercise types and they do indeed walk a lot and some of them manage to control their weight very readily and like that diet. For that reason, um, when we had Lane Norton on the podcast, he pointed out quite aptly that in order to lose weight, you have to restrict something either of course, time or macronutrients, Etc. To arrive at that sub caloric threshold get below the the sub maintenance threshold. I guess one of the things I want to point out is this should be received as again, not a this is better or worse. This is just you now have a ton of options, so, whatever personal preference other factors you get to craft this strategy,

02:29:40 Muscular Endurance: Fuel Sources, Training & Capillarization

Of performance, Aesthetics and health based on your personal preferences. At this point, I'd like to go back to our classic list of nine adaptations. That exercise can induce the first four, of course, being largely largely unrelated to Today's conversation, but that we're covered in the episode that we did on strength, speed and hypertrophy. So, just to remind people, the nine adaptations are number one skill and technique, two speed, three power, which is speed times, Force four strength and five hypertrophy today we're talking about the remaining adaptations on that list, starting with muscular endurance, followed by anaerobic capacity, followed by maximal Aerobic output and finishing at number nine with long duration exercise. So if we could start with muscular endurance, this would be number six on the list of nine adaptations: muscular endurance. How do I build muscular endurance? Why should I build muscular endurance and just to remind me what fuel sources are predominating when I'm training for muscular endurance? Great so remember, muscular endurance is something that's going to be generally in a local muscle. It is not a cardiovascular or systemic issue, and it tends to be something in the neighborhood of say five to maybe even up to 50 repetitions. So this is the classic example. We'Ll give here is how many push-ups can you do in a row? Most people are going to land somewhere in that range. I just said how many sit-ups can you do in a minute how many pull-ups? How long can you hang on a bar um as a dead? Hang things like that? That's muscular endurance, muscular endurance is not a mild run or a marathon, or anything like that, so uh. How long can I stand without breaking posture? This is muscular endurance. A plank a wall sit great, yes, love all these things. Okay. Now the reason I took you on that big long metabolism Journey is so I could help you understand exactly how to train this Factor any of these factors with a more comprehensive understanding of what's Happening, meaning thinking back to metabolism. If I'm going to ask my triceps to do 50 push-ups in a row, what's going to be my limiting factor, am I going to run out of fat no chance? Am I going to run out of glycogen no chance. That's way too few of repetitions. You have a lot left there. So what's going to be the thing that stops me from getting 51 repetitions, either you're going to have too high of a pH rise, so too much acid build up or you're going to have a problem clearing the waste. So really, this is two factors dealing with acid buildup and getting acid out of the muscle tissue and end of circulation, because you have plenty of ability to handle that small amount of acid buildup in your entire body. It'S just you can't handle it in that tiny spot. Now I picked the tricep for a very specific reason: you're going to deal with more pain when you use a large muscle group, like your

quads or your glutes than you are with a small muscle group. For example, nobody ever threw up after arm day, but a lot of people throw up after leg day. Why is that? Look at the total amount of waste that you're dumping into your system when you have quadrupled or 10x the muscle size, small muscle groups are only really going to be challenged in that local area. Large ones will dump so much waste into the system that you'll want to avoid that as quickly as possible, and that's one of the reasons why you throw up after Hard Exercise great, so the reason I'm laughing, because I don't think I've ever thrown up uh from A weight training session, and so it's making me wonder if I've ever trained that hard I've received uh or obtained the progress that I've wanted to do generally over time, not every week every workout every month, but certainly over the 30 plus years that I've been weight. Training, I've achieved the results I've wanted. I have, however, vomited after a long run when I didn't hydrate well, oh or if I drink too much water, sure, oh sure too much water, yeah, you'll, you'll, get that out quick right. I just uh want to be clear because I think some people are getting the picture that, if they're not vomiting, then after their leg, workout that they're not training according to uh your standards Again by the way um Dr Andy Galvin, runs experiments in his lab he's. Recruiting subjects [Laughter,], also known as my graduate students - that's right in any event, sorry to interrupt uh, but I felt it was the necessary Interruption. So muscular endurance, there's plenty of fuel plenty of fuel. You manage acid buildup and you also need to get that fuel out of you. That's going to be a capitalization issue, so the way that we can think about this is capillaries surround your muscle, and the whole point of them is so that blood can come into them. They hit this capitalization that actually slows the diffusion rate of blood down, and so you can exchange nutrients in and get waste products out, and then we get things back into circulation. So the more of those you have, the better you are at dispersing any of these waste products build up whether it's CO2 or the acid. So the adaptation you're looking for here is an increase in capitalization, potentially a slight increase in mitochondria, but the time is too fast right. So we're going to be able to need to do these 50 repetitions and say under a minute or something like that. So getting the mobilization into the mitochondria getting fuel that way too slow. It'S not really going to get our performance here. So what are strategies to increase acid buffering ability and then capitalization? So on the capitalization side, you simply need to train at that ability. So you go close to failure and practice that often that alone will increase, increase blood flow to that local area, which will take you through your process of increasing capitalization, easy peasy specificity. Just to briefly interrupt, I find it remarkable, although not surprising, giving how amazing the human body is that simply by doing some movement repeat like a wall set or a uh or push-ups or dips for that matter repeatedly over and over and over until you reach that Failure Point yep or that quaking point in the case of a wall set that provides a stimulus

for more capillaries to be built into the system, literally the the production or the um, the trafficking of endothelial cells, which make up the capillaries and allow basically more little Pipes to feed the system with oxygen and remove waste products, it's like irrigation right! Imagine you had a giant field and you had two big pipes running down the outside. Well, in fact, if you want to make sure water gets evenly dispersed across the entire field, you'll have a bunch of offshooting little pipes and the more those you have the more coverage you get do we know what the specific signal is that says: hey I failed At this we need more capillaries. I actually don't know what that is. I could, I would speculate, It's a combination of um acidity as well as carbon dioxide, and probably some nitric oxide stuff happening there, but I actually don't know I'm guessing. Nobody knows for sure, because we still don't know, for instance, what the exact signal is for hypertrophy, it's kind of an amazing situation. We know the requirements for getting the results that we want yeah, but we still don't know what the specific signal is um. In any event, what I'm hearing is building more capillaries is great for enhancing muscular endurance and the way to get more capillaries into those muscles is to train for muscular endurance by getting

02:37:30 Tool: Muscular Endurance & Modifiable Variables; Examples

Close to failure, or to some point where you simply can't continue for whatever reason could you give us an example of what a reasonable training protocol might be in terms of the classic Galpin lists now exercise Choice, maybe a few options order, volume and frequency great? What should we be doing? How often should we be doing it, and you know, for instance, should I do wall sets to failures and push-ups to failure, given that this is a local process? I'M guessing that if I do push-ups to failure, I'm not going to increase the number of capillaries in my legs very much correct, so you nailed it exercise. Choice is high Precision here so pick the muscle group and the exact sequencing and movement pattern. You want High Precision. This is the thing if you want to get better at applying hold the plank you're going to do more push-ups two more push-ups, you can do some other stuff, that’s complementary! But really this is a high Precision game. Do the exact same thing for exercise Choice very simple there: okay in terms of exercise order, I suppose this dovetails with volume. Yeah can I combine um training? Let'S say wall sets for my quads and real. You know nearby muscle groups and then do push-ups to failure. Uh and then also do some sort of um pulling exercise to failure. Yep absolutely again pick the exercises. You want the movement patterns you want to do and do them the order almost doesn't matter with the one caveat with larger muscle groups, particularly again, multiple leg activities that will induce a

small amount of systemic fatigue, and so, if you, I guess, theoretically, wanted to maximize Your push-up number and you did a whole bunch of say, split squats and you just did those and, and you you know, did lunges for a mile or something like that. You might actually slightly compromise. You might not, but you might slightly compromise your ability to do as many pull-ups in a row or hold a bend over row or something like that. So if you really cared about that level, then you maybe want to do the one thing. That's most important. First, in general, my recommendation, though, is to do the bigger muscle group first, how many sets and how often should one perform training for muscular endurance and when now the lovely part here is we've moved down the Spectrum past hypertrophy, you don't need a lot of load Here, in fact, the load only needs to be at or slightly above what you want to move. So if you want to get better at moving 50 of your one rep max, you don't really need to train much more than 50, maybe 55 or 60 percent of your one or Max, because if you go higher than that, the repetition count is going to fall And you're no longer going to be training muscular endurance, so you just need to stay right around that number that you want to work on so again if the target is doing more pull-ups and assuming that you have the strength to do it, you check that box. You simply need to practice the repetition range that you want to be in. That's all it takes. You can repeat that a number of times, but because remember the volume is fairly low. The load is very, very low. You can actually repeat these quite frequently, so you won't get extremely sore from muscular endurance relative to traditional hypertrophy, straining because the load is very very light, so you can do these more frequently. If you would like more frequently such as you could do it three or four times a week easy if you would like you, don't necessarily need to three days a week per muscle. Group is probably fine here um. If you wanted to do more sets on a given day and do less days, that would be fine. So if you want to do two days a week and you say wanted to do, let's say you could do 25 push-ups and the goal is to get to 30 push-ups. Just as an example, you might say: okay, I'm going to do sets of 17., and I'm going to do three sets of that. I'M going to do that three days a week. That's going to build up quite a bit or you could say, look I'm going to. Do a set basically to failure, I'm going to recover and do one or two sets that say: 80 percent and I'll do that twice a week. That's going to push the pace pretty well you're going to have a lot of gains from that and again. This is not about hypertrophy, this is about muscular endurance, so I do want to emphasize and again please correct me if I'm um talking out of line here, I do want to emphasize that, because we mentioned pull-ups, if you can't get 25 pull-ups, then and you're doing 10 you're training for hypertrophy you're, not training for muscular endurance. Personally, remember: there's a big cross over here so anytime, we're talking past, like 15 reps we're technically in hypertrophy and muscular endurance got it. So here's the common mistake. I don't want to get bulky, so I'm I'm going to go, lighter and do more

reps and then people grow, and then you landed still right in the middle of hypertri rank right. So like for people who are like, oh my gosh, like every time I lift weights I blow up, I go lighter. I do more reps and I you're still writing the hypertrophy song. They'D actually be much better off training very, very heavy in the one to three rep range, they'd get really strong and they wouldn't grow. Much. Exactly so tell me if this is a reasonable protocol for what I'm going to call the typical person. In my mind, the typical person is somebody who, hopefully is doing resistance training hitting that 10 sets per muscle group per week, minimum yep to maintain or build strength and hypertrophy, but is also doing some long duration training that we'll talk about in a little bit. Maybe throwing in uh high intensity workout here there, some Sprints, maybe some plyometrics, some skill based training, they're doing a bunch of different things to be all what I would call All Around fit: yeah they're, not training for any specific event or trying to maximize any one Of the nine adaptations to the exclusion of the others that person decide okay after um, they do their longer run. They'Re going to do uh Max time a plank to Max duration, they're going to do a wall set to Max duration and they're, going to do push-ups to Max duration and then also do that same workout before they do their high intensity interval training. Some other point during the week and then maybe even do it uh again um on their so-called rest day, just a real, quick, five minutes of sure and in doing so build more capillaries into the relevant muscle groups and build their muscular endurance yep without eating into Their overall recovery too much too much yeah, so again, the nice part about this. Is they don't Hammer you too much you're not going to get tremendously sore? If you keep the load light, the only switch I'd make there is, I would probably do them after your interval rather than before. So you can make sure you keep quality there and you're not compromised by a local muscular endurance when you're actually trying to get a more systemic fatigue with something like a higher intensity interval training. So that would work fantastic, the only other variable we have in it. On here is progression, and this is very simple: try to add a rep or two per week. That’s really all you have to go after. So, if you're up to 22 this week, try to hit 23 next week or for wall sits and planks. That would be added, add time, time, yep and if and if you run into a wall there, just like the same Concepts, we talked about with strength or hypertrophy back it down to more like in the 80 or 85 range and accumulate a lot more practice. That’s going to help a lot with capitalization, as well as asset buffering, so you're going to continue to give yourself signals for up regulation of the processes needed for that, and it's not always pushing you to the end. Failure just like we don't want to always go to failure with strength. We don't want to always go to failure with

02:45:07 Anerobic Capacity: Fuel Sources, Training & Oxygen Utilization

High intensity intervals, either same thing would be happening here. What about anaerobic capacity? How should people train for anaerobic capacity? What exactly are they training for meaning? What is the structural or seller adaptation or adaptations that are occurring that allow for increases in anaerobic capacity? And why are increases in anaerobic capacity good for us? Even if we're a quote, unquote, endurance athlete or we are a recreational exerciser who is not interested in building more muscle, speed or things that I typically associate with anaerobic capacity yeah. So this is really really fun. Remember, anaerobic capacity is the total amount of work you can do for something like seconds to a few minutes, and this is extremely high levels of fatigue, the highest you're really going to see and by fatigue. Here I mean acid buildup byproducts. Not fatigue is in like mentally. I don't want to do this anymore, so if we just think about the energetic for a second I'm going to do say, let's take a really easy example of people have done that thing where you uh you'll, go to the track and you sprint the straightaways and You walk the corners. Remember that sort of thing: yeah, uh, tabatas, 30, on 30 off things like this like this - is what we're talking about in this kind of anaerobic capacity area. Now, here's what's going to happen is fat going to be your limiting. No, we've already made that clear right. What about carbohydrates? Well, if it's a single bout or a two or three bouts? Probably not, but if you're doing this for a long time say you're going to go 30 on 30 off for 20 rounds, you may actually start reaching a point of running out of my muscle glycogen in any of those cases, though, you're going to be running into An acid problem, if you were to continue to do this, multiple repetitions in addition to running low and muscle glycogen you're, also going to start running into oxygen transportation problems, because you're building up a lot of byproducts you've got to continue. You will actually cruise into aerobic glycolysis. This is exactly why the community that I have worked a lot with professional fighters very high level. Boxers world champions UFC fighters. It is a five minute round that you're going to do five times. This is for world championship fights. You get one minute break in between so imagine, going like 30 on 30 off for five minutes, getting a one minute break and doing that five times. Even though the individual ballots are 30 seconds long, the entire thing lasts so long. It is primarily aerobic. You have to have both capacities. You got to get really high anaerobic. You also have to have a lot of aerobic going on. You have you're going to start running into limitations because of heart rate, stroke volume and then even potentially, ventilation. The need for oxygen to be able to come in and clear the carbon dioxide totally out of the system becomes a problem, because not only are you having so much build up for such a long time, you're also using multiple muscle groups. So now this is a very important distinction. Muscular endurance tends to be localized now. This is not right. If you're doing these intervals, you're on an assault bike, you're sprinting up a hill

you're grappling with somebody, you have a lot of muscles being involved, which means all of that waste is being dumped into the central part. You have to clear it and I'm by clearance. I now mean not out of the muscle I mean out of the body, so your ability to bring in and utilize oxygen is going to be a major limitation to your ability to handle this stuff. So what do you do? Well, specificity, wins practice. The exact thing. You'Re talking about so, if you want to get better at sprinting the straightaways and walking the corners, do that you can't always do it, though you're going to run into limitations. So this is when backing off to a lower intensity is going to give you a lot of benefits. We know very clearly if you want to improve cardiovascular fitness, high intensity, moderate intensity and low intensity are effective and you actually probably want to do a little bit of all of them. This is why none of our Fighters would ever just do high intensity training. There'S going to be some moderate, we tend to call this like cardiac output training. You can think of this as like

02:49:23 Tool: Cardiac Output, Heart Rate Zones & Breathing “Gear System”

Anywhere between Zone 2 to zone four, if you like zones, I don't use them personally, so I'm just going to intentionally interrupt you, because this issue of zones has come up a few times. I want to make sure everybody's on the same page. You also mentioned that you don't necessarily favor the Zone nomenclature, but for those not familiar Zone, one two, three, four: all the way up to five is a kind of uh back of the envelope, uh type verbiage for some people and is more precisely followed by, for Other people, meaning for me uh Zone, one - is simply walking uh easy walking zone. Two would be for anybody, the Pace or intensity of exercise that one could perform while still maintaining a conversation, but just barely meaning. If you were to push any harder, then it would be difficult to hold that conversation. Then you'd be in zone three and then zone three four five, as I understand them, are a little bit vague, but maybe you could give us a sense of the breathing patterns associated with each of the zones so that people could map to those uh. When we discuss Zone one through five uh and as I say all this, I certainly um tip my hat to all of those people out there who, like to measure percent of maximum heart rate. They like to use heart rate, monitors, um they're, using any number of different devices. I sometimes use those devices, but in general I tend not to, and I use my breathing as a Rough Guide of which zone I'm in so before we go back to specific protocols for anaerobic capacity. Tell me how you think about Zone one through five and how people might be able to assess whether or not they are in zone, one, two, three or four or five great, so zone five. Is that absolute top thing and we can flag ourselves there? I liked how you flagged one and two, the distinction between three four

and five I'm less concerned with either uh. We will do some heart rate stuff, but not to identify what zone we're in um. The fact is, the distinction between those zones is basically just made up right that not that it's fake, but there's no like rationale there. It'S a little bit like perceived effort and weightlifting. You know how are you at 100 output or 70? You know when you're at zero - and you know when you're at 100 in that moment, but the difference between 60 and 70 is anybody's. Guess totally so we use or the relevance right. So why does it matter if I'm at 60 or 70.? Is there actual difference? There'S not right, so it doesn't really matter in that regard. Um if you're a very highly trained, particularly cyclist things like that then, and you can control a lot of circumstances. Those things start to make a lot more sense, um, but when you're in an open environment like the athletes, I deal with just not going to. It'S not going to matter that much so the way that I approach this is - and I will use this word intentionally stolen directly from Brian McKenzie and his company shift adapt. They use what's called a gear system, and I absolutely love it. It'S what we've been using for a long time so with Brian, with your permission, I'm going to take it right now. Thank you Brian. He gave me the permission to thank you, Brian Brian's, a good friend of of ours, and I do think the breathing gear system is a terrific way to think about the zones and to get a good sense of what zone. One happens to be yeah great, so um. The first gear is your ability to Simply breathe in and out through your nose at a set Cadence. So basically, regardless of how hard you're working, can you restrict your breathing to like a two to three second inhale and then a two to three second exhale? And this is really clever. Actually, because a lot of folks will jump immediately into an over breathing strategy, which means you'll be ventilating more than you need, which actually sends that rer up higher than it needs to be which kicks you higher into carbohydrate utilization. If you're supposed to be in quote unquote Zone, one you're trying to be efficient not fast so using more carbohydrates than you need, is not beneficial. Here, you're walking for the day, you're out on a longer hike, you're enjoying the day you shouldn't be trying to ramp up carbohydrate metabolism. It should be all right, and so this would be getting into an argument with somebody. While on a long walk you feel exhausted. Afterwards and over breathing yeah totally right, okay yeah, so you should be able to breathe at a specific Cadence and generally people are um doing that more frequently than they need right zone. Two uh rather gear two is inhaling and exhaling at whatever rate you needed to be, but still nasal only so it is a force right whatever you need to do, but your mouth is closed. The entire time you've shifted higher up you're burning, more and more carbohydrate. As the fuel source, but you're still able to control that and restrict the nasal breathing now gear, three and four, which is our final ones, there's no gear five gear, uh three and four is like a subtle strength and I actually don't even care about the difference. There I basically use gear one two and then S4, but you're basically talking about either a

nose to mouth strategy or a straight up mouth mouth right so breathing in through the nose out through the mouth. If you can control it that way, you can do the opposite. Actually right, can you breathe in and out through your nose, but the classic one people do is enter the nose out the mouth um again, I really don't even care about distinction. I basically jump from two to four Brian May. Do it differently? I don't actually know um. Four is just mouth mouth right, and this is the case in most sporting applications you're going to be breathing because the nose is restricted right, there's only so much space and, as we talked about earlier, the consequences of not having enough oxygen in or CO2 exhalation. If you're, restricting that this is going to be problematic, so in your actual competition, please go to the mouth. If you need to right, we practice a lot trying to stay nasal only for as long as possible, but that's going to eventually happen when you're doing your high intensity intervals and you're really going as hard as you can you're going to have to go to your Mouth unless you're an absolute Freakazoid - and you can say in your nose - but that's not going to happen right - most people can't get past, say 70 or 80 percent, while breathing through your nose um. I know some people can get higher, but that's the general distinction. So we pay much more attention to those particular gears than we do heart rate zones and zone. Five would be just pure mouth breathing all out and then running into your life. The gear system is just one to four there's. No fifth gear got it, so the gear four would again be mouth mouth breathing as much in as you can breathing as much as you can out got it, and I I appreciate your description of of the gear system and how it um roughly relates to the Zones we've been talking about also um, I'm reminded if anyone wants to experience the relationship between breathing in the offloading of carbon dioxide and your ability to exert effort in anything, a game that a friend of mine sometimes likes to play. When we walk or Jog and talk is he'll say, let's just hold our breath now until we hit that piling or that um uh lifeguard stand on the beach and within seconds you actually can start to. Panic absolutely also becomes very hard to coordinate your action after a little while again be really careful with this. But but it will teach you in a moment in a very real world way, how important it is to be able to offload carbon dioxide, because you're probably not running out of oxygen at those lower intensities, no questions You're, simply building up carbon dioxide and that gas Reflex is screaming to go off and you're actively suppressing it yeah. So the interesting test here is your CO2 Tolerance on Ryan's website. You can go directly there. You can there's a video to how to run this test and then you can put in your numbers and it'll tell you sort of exactly what to do as a result of it. But the CO2 tolerance test is a test of exactly what you just mentioned. So you should be fairly tolerant. In other words, non-reactive can be responsive but non-reactive, two elevations in CO2, so you should see them and feel them, but you should be choosing how you respond rather than adding a reaction um. There are interesting data

looking at things like out of the blue panic attacks, you can actually notice those in blood via rises in CO2, up to 45 minutes prior to the event happening. So there are signals happening in your body that you may be sensitive or not sensitive to the more in tune you can get with that, the better your life is going to be, and even, if we're specifically just talking about exercise performance. So it's okay for CO2 to rise! It'S going to rise! It'S a byproduct of anaerobic anaerobic metabolism! It'S a byproduct of carbohydrate and fat metabolism. As we've established it's going to get there you're going to feel that. However, if you

02:58:10 Tool: Anerobic Capacity & Modifiable Variables; Examples, Nasal Recovery

Immediately go into a panic because of a small increase in CO2. This is a problem, so returning to anaerobic capacity this morning we were training not together. I couldn't keep up with your workout, but I uh, but in the same uh General space - and I did my once a week - maximum heart rate uh one minute Sprint on the assault bike. Sometimes I'll do more minutes, uh, meaning I will do a one minute. Then take some rest and do another minute after some rest, but I decided to do that one minute with you there, so I could learn from you and indeed um. I have to assume that that was largely within the anaerobic capacity Realm, the first 30 seconds or so were manageable, we're getting more and more painful. There was a quit signal going off in my head. You said: there's real magic that occurs around second 40 and indeed somewhere around second 40, for whatever reason it seemed easier, but at the one minute Mark I was happy to stop, because I was really at at least what fell to me: uh 100 output. Yeah. Is that a good protocol for building up anaerobic capacity, keeping in mind what you said before, which is that specificity or precision as you've raised it? Um is important. That is, if I want to train uh anaerobic capacity for sprinting, I probably should have been sprinting cycling. I was, I was on the assault bike, um and so on how many of those one minute all out, Sprints or 30 second all-out sprints on the on the bike, could and should one perform per workout and per week so marching through exercise Choice, yep. Let'S do it um order volume, frequency and progression yep choice of exercises train for what you want to improve. Is that right? Not necessarily so in this particular case, if you have a specific goal, yes, of course, Do It. Um exercise Choice. A couple of things you want to look for you want to pick something that you feel extremely confident in the movement with because you're going to forget your brain very quickly here, because you're going to go into our pain, cave okay. So if you're not comfortable running, don't go run here, you're never going to get to the spot. We need to get to it if you're, not comfortable or if every time you you go on a rower, your low back hurts the next day. Don'T do it if you're not comfortable

using kettlebell swings, you get the point. Don'T do an exercise. You'Re not comfortable with. You also secondarily want to be carefully cautious of heavy eccentric loads, because you're going to be doing a lot of repetitions at a high intensity. So this is where I love an assault bike. This is why a rower is great. Swimming is amazing, running uphill, generally more favorable than running on normal ground, especially if you're, not Runner, don't run downhill. That's a lot of eccentric load. I don't love things like box. Jumps here right because again, a lot of eccentric loading. If suppose, you can jump up land on the box step down, but now you're you're again you're too many things are going in your mind. I don't want to slip and fall. I don't want to smash my on the box. What happens if I'm too many variables pick something that is safer, where you can really focus on your breathing and your posture and the performance all right, so that's exercise Choice and then, within that, if there's some specific thing you want to get better at go ahead. Do it, okay, how many different movements meaning should I do the assault bike and then uh some form of safe, executable, uh, overhead, pressing um? It'S a little hard, it's a little harder to imagine um anaerobic capacity for the upper body unless you have access to a skier or one of these um. What are those things called? The climber machines yeah, the reversal climber, the Versa climber. That's the one! The Versa climber um, you can tell how often I do that one uh, it's a great exercise, so great piece of exercise, equipment, yeah. So we're thinking how many, how many, how many exercises and in what order? Is it going to be two or three exercises since you're involving a lot of muscle groups? Typically, that's a really distinction. Generally, these are going to be total body movements, so you can do something like a ski org. If you want to really isolate your upper body. Great love that you can do lower body isolation like cycling right where everybody's not involved, you can use weights here. You can do some barbell movements and stuff like that they're, just not my favorite choices for most people, too many complexity, things going on so uh. I generally am going to pick total body movements uh, pushing a sled, dragging a sled, sprinting uphill swimming. These things like that are going to be good, I'm seeing now why the assault bike is such a powerful tool because you're using your arms with some degree of resistance, but not a lot of eccentric load plus legs, some resistance, not a lot of eccentric load and Yet one can go quote unquote all out for 30 to 60 seconds, yep and and the consequences of a technical breakdown are minimal. It'S more like you're going to actually have a worse performance rather than an injury rate. So there's just a wonderful invention, uh, because of that, where other things the consequences like say, if you're going to be doing a barbell or kettlebell activity, the consequences of making a technical mistake, you might actually get an acute injury right there. So they're just a little bit higher in the risk scale. How many sets or sometimes referred to as repeats so how many 30 to 60. Second, all out sprints again doesn't have to be running sprinting, but all out effort

would be the better way to phrase it should I perform let's say per week right and then decide whether or not we can divide those up across multiple workouts or whether or not It'S better to do them in the same workout yeah. If you're staying with the same exercise for all of your workouts, that’s a little bit different answer than if you're, if you're modifying them so say, you're, going to do this three times a week and you're going to do an air bike one day, you're going to Do some Hill Sprints another day and then you can do some swimming another day. For sake of example, I'm going to say um same movement, because I think most people are going to be most comfortable with one or two types of movements unless they are really coordinated or an excellent athlete. I think most people can probably find a hill that they could run up yeah and uh an aerodyne or assault bike. A rower things of that sort, yep you're going to have a pro and a con here. So the pro of doing less sets is. You can actually train much closer to truly 100 percent. The downside is volume, slow, okay, so a major mistake people make here is they'll. Do something like um I'll do 20 seconds on 10 seconds off and I'll. Do that for 40 rounds, you're not really actually going that hard on those 20 seconds, so a key! In fact, if you look at the literature and all the buzz and all the positive benefits of high intensity neural training, that assumes you are actually hitting very close to 100 percent. If you're sliding down into like again moderate training stuff, you start to actually be in a spot where you're not getting the total high-end stuff, but you're not doing it long enough to get the low end stuff either. And so you end up in this, like you burn some calories, you probably still enhanced mitochondrial biogenesis and a little bit of capitalization, but you didn't really justify only doing three rounds. That’s where the problem comes in so in terms of a couple of protocols. I'Ll give you how many sets per week it's it's really hard to give a number, unlike the strength, training stuff, where it was easy to kind of land. Some stuff on a typical thing. You'Ll see is like a minimum dose tends to be something like four rounds per day three times per week. Wow, that’s a lot so my once a week all-out effort of sprinting on the assault bike, the so-called Airline bike for 60 seconds one to three rounds of that might be doing something useful for me. But I should probably be doing that two or three times a week if you're going to get to a max heart rate, I generally like to say give me a minimum of one day a week, two's better days per week, how many rounds whatever it takes. You to get to that maximum heart rate right. So in your case, you did one minute: okay, good. If you're going to extend past a minute or two one round might be enough, so, for example, uh, if you want to just do something where I'm going to run a mile as fast as I can that’s all you need to do for the day. You don't need to do multiple. You can do mile repeats if you'd like, but that is really really challenging. I know we've extended the time duration here, but I wanted to go there to show you the time domain matters here if you're doing something like a 20. Second burst: you're going to need more rounds if you're doing something longer like multiple minutes, you

don't need as many rounds to get there. So, in addition, if you're really reaching past this um 90 seconds of of Hell window, it's just going to do a lot more damage to the system, not damaging than bad, but as in there's a lot to recover here. So we need more recovery time from that. A 20 second burst doesn't really challenge. You challenge you in that 20 seconds, but you'll be recovered and fine. A three minute thing is going to hurt and it's going to hurt for many many minutes after that and you're going to still see maybe some performance decrements the next day, depending on what your recovery stuff looks like. So a couple of things to pay play with would be something like this. If you want to try like a classic 30 seconds on 30 seconds off protocol, the literature will show like a minimum of four rounds of that, probably three days a week so 30 seconds. All out 30 seconds rest is one round repeat that four times at least once a week at least two would be better great right if you want to go something a lot longer than that, you might be able to get away with one, but generally two days, A week of this is better if you start actually pushing past like three to four days a week up to five or six, you may actually be causing some problems. Um, there's just a little bit of excess fatigue. That’s going to happen there that you, you maybe want to stay away from. In fact, you can see a lot of endocrinological problems and some other sleep issues and some other things kick in and we'll talk about more of those things as later, but um. That’s the number to get with. If you want to try something more like a 20 second burst, I actually would recommend giving yourself more rest, so you can actually do a higher rest than work ratio. Most people tend to think of this as doing like one to one 20 seconds on 20 seconds off or lower. I love doing like 20 seconds on 40 seconds off. The quality of that 20 seconds becomes extraordinarily high and it's also possible to now get like six to eight rounds. So, as I'm hearing this, I'm going to wager a uh, an offer uh to you and if you say, Okay, um, then to to those listening based on what you're telling me about the relationship between intensity and quality and the need for sufficient duration of this anaerobic Work yeah: how is five to six minutes per week of all out work? That’s pretty good. So what that means for me is. I would do three all out one minute, sprints on one workout separated by a minute or two, maybe more, and I would do that. Two or three times per week just trying to hit that five or six minute per week threshold yep. Actually, I think, uh one of the uh Marty gabala, is the scientist. A Canadian uh guy amazing work. He was done a lot of the the research on high intensity interval, stuff right and I think the number he actually threw out there is some of his original research was comparing six total minutes of work to upwards of like 180 minutes of work throughout um. The entire week and and one of the classic studies was looking at VO2 max improvements and he saw equal, if not greater, improving civil to Max with that. So I think actually the name of his book might be like the six minute workout or something, and so you'd like may have nailed that directly on the head, uh purely by law, but actually, but I also

may be wrong with the numbers. We should probably fact check that yeah Will and also by inference from what you were saying. You know if you're going to do this 20 seconds on 40 seconds off and you're doing more rounds or one minute all out. So the way I'm going to think about this, if it's okay with you, is for five to six minutes a week. I am sprinting yeah for my life correct, but I'm sprinting for my life with good form in whatever movement. I happen to be doing, and I can do all of that in one workout, but I'm separating out bouts of 20 seconds all the way up to one minute yep by the necessary rest. In order to recover my breathing get back to Pure nasal breathing, maybe Zone one zone totally totally and then hit it again if you're going to do the one minute thing like you, do I actually generally encourage one to three minutes of rest before you do the Next round, and probably up to four to six rounds, that would be your six minute number there. Now the caveat there is we don't worry about heart rate recovery. We worry about exactly what you mentioned, which is nasal only recovery once you can get back to that. Give yourself another 30 seconds or so, and then you're ready to go for round two. This is where it gets fun, because I can imagine challenging myself to get on the assault bike for one minute of kind of warm-up, very low intensity each morning and then Sprint for a minute and then head off into my daily routine. No okay, that if you're going to do that, though, you need to give me three minutes of nasal only breathing before you go back to work. We need to download, and there are people in my life. That would love for me to engage in more nasal breathing because it will have me speaking less so no problem chances are I'm going to use the

03:11:45 Tool: “Sugarcane” Endurance Protocol

Um two or three workouts per week of a one minute, all out, maybe I'll, try the shorter protocol. Can I give you one fun protocol to try here please. So if you have a, you can use this on any equipment um. But I learned this from another mutual friend Kenny Kane. This is a great little. It'S a little test, a little a little game you can play with yourself and the only way to play this game is you're going to lose, which is really really lovely. So you can do this at any rate, you can do this for any duration of time, but two minutes is a good number Okay, so you have to do this in somewhere, where you can no distance, so this could be running cycling. The the air bike is what I use the first two minutes you're going to cover as much distance as you can possibly cover in two minutes and you're. Going to note that so let's say you covered 400 meters right, okay, great you're, going to rest for two minutes: amazing that next round you're now going to go for distance. So you're going to cover the exact same amount of distance. You covered in round one which in this example, is 400 meters, and it

doesn't matter how long it takes you. It may take you two minutes and five seconds, two minutes and 10 seconds, because you're a little bit fatigued from round one round. Three you're going to now come back and do that exact same time domain that you did in round two. So if it took you two minutes and five seconds in round two now round, three is going to last two minutes and five seconds, and you want to see if you can cover a greater distance, 405 meters, 410 meters, and then you did in round one and The beauty of this little protocol six minutes total of work right. But if you slack in one of the rounds, you just make the next round harder. Is there any rest between rounds? Yeah two minutes always two minutes rest you don't have to, but this would be my recommendation. Kenny king came up with this. I don't know if he came up with it. He taught me this thing. We both know Kenny and he's an incredibly nice and Incredibly skilled trainer um, I'm going to call it the sugar cane yeah, it's so great, because it sounds really painful and if you go out too hard in round one you're in such big trouble round two. But if you go to Easy in round one you're going to get absolutely obliterated in round three. So it's like a wonderful thing and you can pick that number as a

03:14:02 Anerobic Capacity, Training Progression

Standardization and then just try to improve that a little bit per week, so progression is the last part of this whole thing that we haven't got to yet before we move on um and the way you want to progress. All of these things is you can time stamp again how much work you can do and then just try to do a slightly higher amount of work, five percent or so every week or you can add a round which is a really nice way, so um uh In the in the research studies that have been done, they're going to do things like week, one you'll do three rounds week. Two you'll do four rounds. Three you'll go five rounds, you'll like add a round until you get up to say six or seven or eight rounds at the end of the protocol. So that’s a really nice way to go about it or you can cap the rounds and just try to get more work done in that same amount of time, meaning go more intensely correct. Get you know, get further distance in your 30 seconds or your 45 seconds or whatever um. I want to encourage people to go as low as 20 seconds. That’s going to allow you to go very very fast. That’s going to actually challenge that phospho creatine piece. A little bit I want to encourage people to also go as high as 90 seconds, so the honest way, the way that I will do it not that it's about me, but just as an example of something you could do, I do something in the 15 to 22Nd burst range and I will generally hedge towards a two to one rest to work ratio, so I'm probably going to rest 40 to 60 seconds. That’s true! That’s to make sure that 20 second burst is extremely high quality cool. I'M also going to do something in the 30 to 50. Second range. Okay, I might go one-to-

one work, rest ratio, the quality of those 30 seconds is going to come down, but the acid buffering is going to be extraordinarily challenged. I also will do that with a triple or quadruple rest range, so again, 30 seconds on maybe two minutes off now I won't be able to be. I won't be working on my ability to handle um the waste product build up there, but I'll be working on. My ability to produce more force over that time, which is another skill set and then all the way up to say what you do a minute 70 seconds and you can go one to one there or up to three to one um you're going to be working On a little bit of this different thing, but that's exactly how we hit both sides of this equation, working on dealing with waste as well as actually working on bringing in nutrients and getting that system a little bit more effective. So you could set that up across your week and just it could be something like day. One is that 20 second burst window day. Two is that maybe 60 second window

03:16:40 Tool: Maximum Aerobic Output, Training & Modifiable Variables

And then day, three is maybe one all-out effort and we're done there. Let'S talk about the specific protocols and adaptations related to maximum aerobic output or maximum aerobic capacity, as it's sometimes called sure. Now we're moving past like that couple of minute range into, like the you know, five to 15 minute range, but at a maximum intensity. So what's the highest, you can go from there. We'Re not talking about our last category of long duration here. Well, the beautiful part is, we've already explained a lot of it, because it's very similar to what we just talked about with anaerobic capacity. It is primarily going to be a problem. I'M dealing with waste products, especially at the end. It'S not enough total distance to be running out of muscle glycogen, though it may start to creep down a little bit. Fat'S not going to be an issue, but certainly more oxygen. Transportation is going to be an issue, so we're just hedging a little bit more towards that side of the equation towards the end of that workout. No doubt about it. Clearing out waste products is going to be a huge issue, but really oxygen. Demand. Delivery is starting to take more of a prominent role, because we have had more time to clear the waste and, if we're not good at that, we're going to be failing earlier than we need. So the training for that needs to be a little bit at that exact same so a classic thing here is a one mile test right. This is going to last for most people somewhere between five and ten minutes, you're sort of right in this window. If you just want to practice that once a week, we're done here right, exercise, Choice, same thing, we talked about right pick, an exercise you're comfortable with that you can actually do and you can progressively increase in terms of the intensity. Um you're not going to be you don't have to stop and change your exercise. You'Re not going to move around. It'S like a circuit isn't great here,

because you got to put one Implement down pick up another one. You want to be doing something where there is literally not a second of off switch, so similar exercise Choice, principles we just covered. If you going to, become a real Savage and you want to do repeats here, you can um endurance. Folks will do that a lot. One of my repeats 800 meter repeats things like that or I'm not sure what the swimming distance equivalents would be, but swimmers we do this constantly, but you don't need to. This is really hard. It'S pretty hard in the system. It'S very good for you, one to twice a week of hitting this. I think you'll be in a really really good spot frequency. We sort of just covered. We covered exercise, Choice volume, we just sort of nailed and intensity is basically running you up to the top. There now - because you can only do that so often you want to add in another 40 or so percent of your time being lower intensity support work for that. So this is something probably less than 85 percent of your heart rate, but higher than quote unquote zone. Two you got to be working here. This is not. I could have a conversation Pace. This is higher than that. It'S in between conversation, pace and the pace. I need to be at to run my fastest mile. I'Ve ever done, that's that middle ground, and you need to train that so that you can continue to work on capitalization auctioning Transportation, but you're not burning down the house getting all the way up to 100 100 plus percent of your vo to Max. Could I use a uh accrued version of this where I say: okay, I'm going to exercise for 10 minutes, I'm going to go as fast as I safely can, and every week I'm going to measure how far I travel yep in that 10 minutes love. It probably not on the same day that I'm doing the anaerobic capacity work, probably not, if you're, probably okay, to do after a strength, training or hypertrophy workout. As long as I didn't train legs you could um is probably going to compromise. Recovery is the way, so I would, if you're going to do a session like this. I would probably do it on its own day. Unless you wanted to do something like speed or power, then you could roll right into this and have no problem, maybe a strength day a hypertrophy day, I'm not sure um. You would do there because again, especially if you did any sort of lower body exercise, you're going to be compromised here, but remember these tend to be full body movements. So, even if you did arms that day, your arms are going to be compromised and you don't want to fail this because of local muscular failure all right. So now I've got my work cut out for me, I'm going to be doing five to six minutes per week of all out work divided into 60, 20, a 60 second bout with sufficient rest, and I'm going to give myself 10 minutes a week of, in my Case it'll probably be running as fast as I can, because I do enjoy running and I can do it safely, um, maybe uphill and see how far I go yep if you want to combine the two. So if you're just saying hey, I'm bought in Andy like I want to do both of these things, they are similar, but they have independent benefits. I'M convinced. How would I build these into the same week? Um, maybe do one of each that still gets you at quote unquote two days per week, where you're

going to hit a hot maximum heart rate. So we already checked that box off. So one day can be a shorter length interval repeat one and the other

03:21:58 Tool: Long Duration Endurance, Training, Circuits

One can simply be a 5 to 15 minute maximum work and you're done long duration, endurance, exercise, the stereotypical endurance exercise sure how far how long, how fast or how slow, rather should I go, and here I'm going to Venture that exercise choice is one that we Could click off even at this point in the discussion, because obviously it's got to be something that I can do for a long while without getting injured, uh overuse injuries, um there's a little bit of novelty. We can actually throw in here. So one of the things I love to do for long duration and endurance for people who don't love running cycling or swimming, is you can do a really cool workout, any number of things where you can put a little circuit together as long as there's not a Lot of downtime between one circuit to the next time, you can actually do something as simple as like. Maybe you're going to do Farmer's, carries and you'll. Do that for say three minutes and you'll set those down and you'll go straight into a plank for a minute and you'll pick that up and you go straight into maybe body weight squats for two minutes. Then you go straight into another exercise and you can sort of rotate things around. Maybe you can do even some like Shadow Boxing stuff or some jump rope. You can do different gymnastics movements and body weight movements, and you can run that thing through and you can basically get the exact same thing accomplished and not feel like you're doing. Oh, my gosh, this mind-numbing type of training. If it feels like that to you another way, you can do that to actually even simplify it. Even more. We'Ve done this at Kenny. Kane'S gym plenty of times where you just maybe even pick three machines, so you're going to I'm going to go 10 minutes on the rower. Then I'm going to go 10 minutes on the treadmill and I'm going to go 10 minutes on the bike. You can actually knock a 30 minute quote-unquote steady state session out in and not feel those problems. If those things happen, so you can actually have a lot of fun there. We will do a lot of times with our Fighters. We'Ll do things like put a very low load, I'm talking sub 50 of your max on a barbell and you're going to Squat and you're going to. Do you know maybe a minute you're going to put that down and then you're going to go over and do 50 of a bench press you're going to put that down you're going to go over and do 50 of uh of a crab walk and then you're Going to go over and do another one, and you can actually run through this entire thing. You don't hit that many reps in any individual movement. The load is very very light and you can keep heart rate, basically a steady state and do 15 or 20 or 30 different exercises, and it's actually like fairly fun and

engaging to do. And it's a little bit more specific than trying to get a 275 pound. Nfl player to run for 30 minutes, which is not going to be good. So I'm just chuckling because I love to run outdoors and I've enjoyed runs on all my travels and I find it to be a great way to see different places. And I like moving through space, but there are weather conditions and times when that's not an option. So what you described is a terrific alternative. I have to assume that the specific adaptation that's occurring here is related to the fat burning system and again that doesn't necessarily mean

03:25:13 Long Duration Endurance, Capillarization, Fatigue & Breathwork, Technique

Fat loss correct overall, but fat burning system, and yet I do have a question which is: can you build enhanced microcapillary systems into the muscles uh? By doing this long duration, cardio yeah, absolutely can in fact, depending on which paper you uh like more than the other papers. You may even find evidence that this is a superior method than anything else. A steady state endurance is very important. I used to not like it as much there's just so much evidence now. That suggests it's probably a really good thing for basically everybody, maybe for some individuals, it's not in all year of their training. But if, if you're not a high-level athlete or have a very specific goal, that's right in front of you. It'S probably best to do at least 20 minutes as a minimum. Maybe 30 minutes of some steady state exercise once a week for basically any training goal outside of again a couple of really specific scenarios that are happening. The other thing that kind of kicks in here that we haven't really talked about is now we're actually reaching a position where fatigue of the intercostal starts to play. So diaphragmic fatigue starts to run an indication, so we forget generally breathing is a contraction to open up the lungs to change pressure, so the air will flow in and then the exhalation is passive right. It'S just a muscle's been stretched. It goes back to it's resting when you get to a maximum heart rate. Inhalation and exhalation become active, so you're, squeezing as hard as you can to open up and you're squeezing to contract to blow air out you're going to get fatigued that system right over time. You have contracted contracted open up if that system starts to get fatigued. You start running into failure here, so you need to practice that - and this is when all kinds of things like breathing drills to just simply training in this fashion, there's all kinds of exercise devices for your lungs and when we say that, that's what we're really talking About the musculature around the lungs needs to not fatigue, so that's the only other little component I wanted to throw in here. If we're not talking about acid buffering, which in this particular case is not a problem anymore, the time domain is long and slower. So we have plenty of time to use fat as a fuel. We also have plenty of time

to use anaerobic and aerobic glycolysis and clear out waste products. So we don't really see pH being a problem with this type of exercise. You may start running low on liver glycogen if you're going a very long time, muscle glycogen may start getting low, but not really. These are huge issues you're going to run into maybe a little bit of stroke, volume issue but and the intensity is not high enough to become a problem, you're more likely to break down posturally or breathing mechanics than really anything else. Unless again, that duration really gets generally past two hours for most people, so those are the things that are going to limit us. So how do we improve it? What do we train? We went through the exercise choices. You also need to make sure you're training, your intercostals. We need to be training our diaphragm in some fashion. Again it can be. The exercise itself can be your normal training. The thing you need to be careful of here - and this is actually true for all the things we just talked about when we think about fatigue and we think about failure and endurance. We really need to pay attention to technical breakdown. That is always the marker. We look for so when we, when we go through our stuff with our athletes, and they quote, unquote fail, or they finish. That's generally, because we saw a massive technical breakdown, you're done like you're over there. It'S not always the case during all year round of the training, but this is something to really pay attention to. So, if you're on that bike and you're 40 seconds in and all of a sudden posture starts punching over, I may stop the test. I may stop the training it's like no well, we decided failure was is when you lost your Technique to some sufficient level. So you want to pay attention to that too, because that's going to determine your ability to perform well as well as maintain

03:29:10 Weekly Combination Training, Metabolic Flexibility & Longevity

Efficiency, which is a really big problem here, tell me if the protocol, I'm about to describe, would be a reasonable one for people to incorporate 60 to 120 Minutes of long duration work per week. So one way to accomplish that that I often use is to head out for a weight vested hike. It'S not a heavy weight vest. It'S maybe I think it's eight or ten pounds it's one of these thinner ones, and if people don't have access to that, you can bring a backpack with some items in it I mean it can be. You don't even need external load, it could just be your body, okay, great and and do some hiking at a at a fast enough clip that breathing harder than I would be. If I just kind of shuffled along yeah, I might stop here there drink some water. No big deal, but I can carry on a conversation if I need to so it's a Zone two-ish, but probably pushing a little bit harder than that for that duration. Yeah not a lot of um deep soreness occurring after this, maybe a little bit of achiness and some stabilization muscles that were

used. That may not be used Too Much, especially if I've been sitting a lot during the week. Um kind of reminds me of how much I've been sitting but doing that all in one Long Afternoon, um, typically on a weekend or doing two shorter sessions throughout the week, maybe 45 minutes and 45 minutes and then working up the progression to longer longer duration seems Like that would be something that most people should be able to do, yep and that it would weave in well with any resistance training or the uh, anaerobic and aerobic output capacity work that we talked about just a moment ago. Great, that's a fine version to do it if you want to go shorter and bring up the intensity a little bit, so you want to keep it more to the 30 to 60 Minute range and go. You know closer into the. I can't have a conversation right now, but again I'm not at a blistering heart rate um. Then you could probably get that same thing done in a smaller time window if that was a consideration. So if you wanted to blend all three of these together, you have a lot of wiggle room right, so you could do something like order. If we're talking about this type of training, you could do this first and then finish with either one of the higher intensity stuff we talked about, so it could be roped into the same thing. It could be its own independent day. It could be your sort of active recovery day. It tends to be fairly restorative, as you alluded to a little bit there. So it's not that big a deal to do this on your quote-unquote off day, if you're, those, if you're, that type of person who, like even on your off day, you have to do something physical. This is fine right. If you wanted to do it on a lifting day, especially if it's a power or strength date, it's probably fine. If you wanted to do it before the workout or after it, either way - you're, probably okay, probably best to do it after. If the primary goal is one of the strength, training adaptations, if it's not, if this is a primary goal, do it first amazing? If you wanted to do it in the combination with the other interval stuff, you could do it fine there. You could do it before or you could do it afterwards. I actually have no problem doing it afterwards, because that, in effect, especially if you say nasal only during this training will help the down regulation go, and so you could finish that fairly well down regulated. Actually so it's kind of like a nice way to get thoroughly warmed up, go really really hard and then give it a nice 20 to 30 minute slow back down and by the time you finish, maybe even on a three minute: walk nice, slow, nasal, breathing. Four. Second inhale four seconds and yeah: maybe five even play with the numbers a little bit, then maybe you don't even need to do the down regulation breathing afterwards, you'll be in a good spot. What you wouldn't want to do this before do your intervals finish your intervals. Throw up lay on the ground, sweat all over the gym floor, get up and go back to work. That's probably not our best strategy. As people are hearing this all they may be thinking wow. This is a lot of work to do, but I've been keeping track of the math here. As I'm sure some of you out, there are as well and we're really talking about 10 minutes of the of running or sprinting on the bike or rower once a week. We'Re talking about

six minutes or so of the much higher intensity, but short bouts divided into rounds of 20 to 20 seconds to a minute with with rest in between and then some longer duration work out of 30 minutes minimum, but maybe as much as an hour. Even two hours, which in total doesn't really equate to that much time, especially if one can access these things right out their front door or at home and as we point out, you don't need any specialized equipment to do that. Oh and I forgot the um muscular endurance that I wasn't trying to cheat, there um some muscular endurance thrown in as well. So that brings me to a question which is, if I'm doing my training for muscular endurance each week for anaerobic capacity and for maximum aerobic output and long duration, and given that all of that is going to take roughly two hours for the typical person total for The entire week, which I would argue, is going to give you back so much life literally in terms of longevity you're, literally going to earn back years of your life productivity, you name it offsetting all sorts of uh metabolic issues and uh enhancing your sleep and improving Mood I mean there's so much data, so much data pointing to all those positive benefits. If I do all of these things and I'm fairly consistent about them, am I going to be metabolically flexible? Am I going to have a well-developed fat burning, carbohydrate burning system and will I be essentially fit? I mean this is not leaving aside issues of strength and hypertrophy which were covered in the previous episode. Will I be fit? I mean, to my mind: the ability to you know Sprint very fast if one needs to the ability to go longer duration, if one needs to and the ability to do something in between as well as you know, hold a box overhead if necessary, while installing a Shelf or something like that, these are the realities of life and to me represent real functional World Fitness. If that’s the case, is there anything that we would want to add to this program, or would you consider that a fairly comprehensive and complete endurance training system, if we remember the target, which is I want to have energy, I want to look a certain way and You want to be able to do that for the duration of your life for a very long life. This style of training, where you incorporate all of those areas of endurance, gives you all of the necessary adaptations. One would need to execute all of those things. Remember, fat loss or Weight Management is not best done with any individual style of protocol. So if you do a little bit of all three of these you've checked that fat loss box, you don't need to go out and do anything separate for it. You'Ve done all the things then, to cover Aesthetics from that side of the equation. Right. You'Ve done the things to both enhance mitochondria, to enhance blood flow increase, oxygenation and manage fatigue and waste development boom energy is there fatigue? Is there I'm not going to get tired or have to quit or stop or sit down doing any of these activities? I want at the same time, if you look at the literature on mortality, one of the strongest predictors of how long you're going to live. Is your VO2 max, so we've set up a scenario in which you're going to hit all three of those primary goals by doing a combination of this training, you're not going

to miss any plausible adaptation from endurance, training and you should be set for regardless of your Goal incredible and, as I understand totally compatible with strength and hypertrophy training, provided that your goal is to also be strong and also selectively, hypertrophy or

03:37:23 Tool: Mixed Endurance Training, Half Marathon Example

Generally hypertrophy your muscles or maintain your muscles for many people that are listening to this, I'm guessing that they have an interest in building more endurance, but not just the ability to go further. But the ability to go a given distance at a higher speed and to do it with better form and to breathe better and to feel better before during and after for those folks. Maybe you could spell out a program that combines these different elements of endurance and does so in a way that informs how, for instance, the higher intensity short duration. Sprints would be expected to improve their longer duration work and how perhaps their longer duration work can progress. If they are careful to include some planks and some wall sets and and things of that sort, I asked this question specifically because I have to believe that, while there probably are some folks out there, they're looking to just maximize their plank from week to week to Week, typically, it seems that people fall into these categories of either wanting to get stronger and get bigger muscles to varying degrees or to get better at endurance or to get better at everything overall right now, I'd really like to just focus on what you think is A nice Contour of a program for the person that wants to get better at endurance, but do it with more speed, more stability and just feel like a strong endurance, Runner cycle or swimmer, or whatever happened to be their endurance event. Okay, great! So, let's just give an example: maybe you want to run your first half marathon, something like that? Okay or maybe done a couple times before, but you want to get better at that time I would probably put somewhere in the neighborhood of 60 to 70 percent of your. You know mileage in the moderate intensity Zone. Okay, so you need to accumulate mileage and you need to be able to handle what we call the tissue tolerance. So in this case your feet need to be able to handle 13 miles of pounding. Okay, it doesn't matter how much high heart rate training you do or your fat deliverability none of that matters if your feet are blown up by mile, eight Okay. So, in addition, we talked about how even training in that 70 to 85 percent heart rate zone is quite effective at oxygen, delivery, fat utilization, capitalization, Etc. So you're going to get a lot of direct endurance benefits from that work, you're also going to be working on. What'S honestly going to be one of your limiting factors, which is that tissue tolerance and that pounding okay? In addition, you need to be efficient with your Technique

and you need a lot of repetitions for motor skill development, so you want to spend most your time there. It'S easy to recover from it's not extremely demanding and challenging awesome. That leaves you with another 30 or 40 percent of training. I would spend 10 percent of that in that, like 20 second burst area, you're going to drive up fatigue extremely high and you're going to really maximize your ability to recover from waste production all right great. I would spend the remaining amount of time, either on a little bit of actually maximum speed stuff that could actually be in the 20 second burst, if you're really trying to go as fast as you can at the beginning of that exercise and then the rest of It I would spend in that other Zone, which is more of like the five to 15 minutes, but you're probably going to want to repeat those - and this is when things like 800 meter run rest for double the time and then repeat that two or three times You actually need that in this scenario, because you're going to need to be able to be running for two. Most people are going to, do a half marathon and maybe around two hours or so something like that, and so you want a little bit of what we call repeated endurance right so be able to handle that higher heart rate come back down. Do it again at the same time, that’s actually how you bump your mileage up. So, instead of having this do more of these long duration, distance runs, you can still get maybe five or six miles down in a day if you're going to do a one mile, repeat or whatever number you're looking at so for a lot of people, that’s kind Of how I would structure it um, that’s honestly, it's very similar to what we laid out in the previous conversation, which is getting to this idea that more than 50 percent should be basically practice a little bit of work at the very top end of the spectrum. But not too much and then a little bit of work at the other end, and you should be in a good spot. A major mistake one would make here, is only doing the long duration, steady state, stuff and just sort of saying. I'M going to run a five mile. This was a week and then do six miles next week and seven. I said that might work for you. It'S. I think we have enough evidence at this point, both in the scientific realm as well as most of the coaches. I think in this space would agree with me. Is that’s a sub-optimal strategy, so it could work, but we can do better and in terms of the structure of a program like this, I realize that those structures vary tremendously. Different coaches and different books and different programs are going to say: oh, you should run Monday through Friday with weekends off or every other day, but in terms of this 70 percent um thirty percent divide where seventy percent is going toward the specific event you know doing. The kind of work that you're going to do during this specific event that you're most interested in cultivating or improving and the remaining 30 coming from other sorts of uh of supporting were work. How should one thing about Distributing that other thirty percent? Should it be all geared towards maximizing recovery for the 70 or in other words um? Could I do all that 30 work on one day? I probably would split it into two days: um, that’s the reality is so. If you're thinking man coach wants me to train six days a

week, my schedule is tight. I can pull off four to five. Okay, great. What I might say is two of those days are just your your tempo right. This is what, like a runner, would call this like Tempo training. I'M kind of in that space remind us what tempo training is 80 effort range, where you're like running at probably the same stride length and and rate that you're going to run your race at maybe a little bit lower, but something similar you're practicing skill you're accruing Mileage and you're getting a little you're getting work in for sure work, but it's not absolutely the fastest. You can Sprint, it's also not conversation, so this would be the um what before we refer to as the 10 minutes of of fast running or ten minutes of fast run, this is lower intensity than that got it. This is uh. This is work. Accumulation got it. This is practice stuff um. Then one of the days a week I would probably enter in that 22nd. 30 second burst for a little bit of speed there, and then one of the other days is when I would do that. True high intensity as hard as I can for hitting a VO2 max something like that, so that's probably how I'd break it up. If I had like four days a week, if you had five, you can maybe add in another day where you do more of that volume accumulation practice work, but that's that's a pretty good split. Well. This is the point in the episode where I say thank you. Ever so much you provided an enormous amount of incredibly interesting, clear information. That's also actionable. I do feel as if I far better understand endurance in its many forms and even the seller, underpinnings of that and even sub-seller underpinnings of what endurance adaptations are and how to Foster those through specific protocols, things that not only I can do tomorrow, but that I Will do tomorrow and where I hit my pain, points I'll understand, what's happening and the adaptation that I'm triggering when my legs are burning or I'm sucking for air through my mouth or I can calmly move along just through nasal breathing. I will now know what's happening in my body and the specific adaptations that I'm triggering. I think you also highlight something that is vitally important, and I've never heard it phrased as clearly as you did today, which is that it really doesn't matter how one seeks out to achieve fat loss, provided certain criteria are met, even while certain forms of exercise tap Into fat stores more than others, and you beautifully Illustrated the relationship between energy utilization and breathing and the fact that we literally exhale fat to some extent, of course. So once again, thank you. Thank you and thank you. I know I'm not alone in um recognizing this information as incredibly interesting and actionable, and indeed I do plan to put it into action, as I hope many of our listeners will as well. Yet again, the pleasure is actually all mine and uh. I actually really appreciate the fact that you, let me go so far into metabolism. My PhD is in human bioenergetics, so anytime I can go many hours into metabolism, I get very excited and I don't typically get that leash um in this format. So I appreciate that I know you understand your audience. Will love that, hopefully Oh They'll love it, and I think that they'll especially love it, because they understand that if one can wrap their head around even just

a small fraction of the mechanisms that underlie a given protocol, it gives both tremendous depth and meaning to that Protocol and makes it so much more flexible for people. They can really think about what's happening as they're engaging in a given protocol and know exactly what they can expect in terms of results. Great we've been on a bit of a journey here. We'Ve covered a lot of ground with speed, development and strength and hypertrophy, and now we walk through you know, probably several hours here of of endurance. What I would love to do next is to just give you a more straightforward, not as much background, not as much metabolism. None of the mechanisms right into protocols for someone who says look I want to hit those marks you keep talking about. I want to look good, I want to feel good and I want to do that across my lifespan. How would I build all these things into a protocol that actually covers maybe the entire year, and how would I would be able to repeat that year after year, so I almost have this Evergreen sustainable, year-long, periodization structure that covers all the nodes I need to. If I want everything, we've talked about in these nine adaptations in this short Series, so I

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again for joining me for Today’s discussion about fitness exercise and performance with Dr Andy Galpin, and as always, thank you for your interest in science. [, Music,],