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- Announcer: Bulletproof Radio, a state of high performance.
- Dave: You're listening to Bulletproof Radio with Dave Asprey. Today's cool fact of the day is about teeth. No, not your teeth, but fish teeth. And you've probably started asking yourself, "Dave, where are you going with this fish teeth?" But some scientists looked at piranhas' teeth. These are razor sharp teeth that in horror movies from the 70s will strip all the meat off your bones and things like that.
- Dave: They have a single row of teeth on the upper and lower jaw like humans do, and they lose teeth on one side of their mouth all at once and a fresh set comes in five days later, then it simply happens on the other side of the jaw. There's always a set of sharp teeth, but just on half the jaw, which is weird. And that way, there's never anything dull and scientists really thought this is because carnivorous fish are used to eating scales, fins, and flesh.
- Dave: The problem is that Piranhas share exactly that trait with a fish called the pacu, which is a cousin of the piranha that eats plants. Obviously, for that reason, the pacu are smaller, weaker, and have lower testosterone levels and a hard time reproducing. Okay, maybe not, but that's what happens when humans do that. Anyway, what they figured out is that eating hard seeds and tough stems also damage fish teeth, so cycling through using one side of the mouth versus the other is a good strategy.
- Dave: And these fish have a double row of teeth on the upper and lower jaw. What this means for us is that whether or not you're carnivorous or vegan, your bodies may adapt in surprising ways and maybe we can't just look at teeth to say what we're supposed to or not supposed to eat, so there's been this long debate, "Oh, human teeth are this or they're that."
- Dave: Probably you might be able to eat some plants or some meat with your teeth and that doesn't mean that that's the only thing you should be eating, either one way or the other. Sorry if you're on the carnivore diet for the rest of your life or that's your plan, or sorry if you're on a vegan diet for the rest of life and that's your plan, and both of you will probably fail eventually and have a bite of bacon because, bacon.
- Dave: And in terms of vegetables, we all know cucumbers are the gateway drug of plants, so you'll probably have one of those too, and that's how it's going to be, if not avocados. Hey, avocados. All right, onto the show. We're going to talk about something that I dearly love, which is avoiding exercise, or actually, more accurately, we're going to talk about exercising the minimum effective dose and some other things you probably wouldn't know about how human physiology responds.

- Dave: And that's because I've got a really, really cool expert on... who's a Professor of Exercise and Sports Science and high altitude exercise physiology at Western Colorado University. His name is Lance, and I have already checked with him. He is not related to the doctor who [inaudible 00:03:31] and does not want to exterminate, no.
- Dave: Exactly for people of the a million people here that's laughed at that joke and Lance laughed at it, but if you don't know what I'm talking about, just... you need to get up on your doctor [inaudible 00:03:42] come on man. Okay, Lance, welcome to the show.
- Lance: Thanks, great to be here, Dave.
- Dave: The reason that I had you on is that I did a recent podcast with the founders of CAR.O.L, the exercise bike that uses AI in order to give you really the minimum effective dose exercise in nine minutes a day. The response to the podcast was really positive and I asked them for more research and they said, "Why don't you talk to the guy who did research on our minimum effective dose exercise thing," but it was research that was funded by the American Council on Exercise.
- Dave: You're the professor who actually said, "Hey, let's see what's going on in people's bodies and brains from these different types of exercise. I want to pick your brain on this because if you can free the people listening to this show from having to go spend an hour a day in a spin class, so they can do that if they want to, but they don't feel like they have to, I feel that extra time could be spent meditating, playing with our kids, connecting with our community or just eating Piranhas." You eat Piranhas, don't you?
- Lance: Maybe once or twice.
- Dave: I don't know, I think you can eat them. I've never eaten a Piranha but I would, just because of the irony. Now, what got you into specifically high altitude physiology? Because there's tons of exercise researchers out there, but the high altitude side, that's a rare breed. Why did you want to go high?
- Lance: One, where I'm located, so Gunnison, Colorado's located at nearly 8,000 feet, and my past includes interest in endurance performance and one of the traditional strategies for improving performance is to exercise at high altitude. More recently, I'm interested in high altitude because it appears that hypoxia that's linked with high altitude not only helps with performance, but is also important for modifying various cardiovascular disease risk factors.
- Dave: Brief exposure to hypoxia might actually be really good for us.
- Lance: Absolutely.
- Dave: And I've been reading some papers recently about something called HIF, HIF-1, HIF-2, hypoxia-inducible factor. Are you up on that?
- Lance: Absolutely.

- Dave: Can we talk about that? I didn't realize we were going to get to go there because we're going to talk more about exercise physiology, but I believe there's a mass of stuff happening. I do an intermittent hypoxic training at Upgrade Labs. What is HIF and why should people care about it?
- Lance: HIF-1-alpha is a protein that is normally regularly produced in our body at sea level. However, in a normoxia or sea level environment, it degrades and so it doesn't really have any effect in our body. However, when exposed to hypoxia, whether it's the real thing or whether it's simulated, HIF-1-alpha is preserved and it upregulates gene expression for really dozens and dozens of different molecules, proteins, hormones in our body.
- Lance: Some of the key ones that my students are usually interested in general community members usually interested in one is, it stimulates EPO so it produces more red blood cells as a result of HIF-1-alpha being preserved. It produces an increase in VEGF or vascular endothelial growth factor, so this promotes more vascular [inaudible 00:07:17] formation. It improves GLUT4 transporter protein activity so we can move our glucose from our bloodstream into our cells more effectively, and that's just really the tip of the iceberg.
- Dave: Now, it's really interesting, people with chronic mold exposure like I used to have, and one of the things I've done a documentary about... moldymovie.com if you guys haven't seen it, it's free and worth an hour of your time. But the things that happen are you get a decline in VEGF and a decline in EPO. These are things that I actually quantitatively had, and it's amazing.
- Dave: Toxins in the environment can do that, they manipulate those hormones, but maybe holding your breath for a while or more likely getting a little bit more hypoxic via more extreme methods can not only recover from those things, it can also give you performance improvements that are pretty darn amazing.
- Dave: What is your recommendation for people who aren't going to sleep in an oxygen deprivation tent to do stuff like that? If you're listening to the show, you're thinking, "Oh, that sounds cool. I want more VEGF, I want more EPO. Is there a poor man's version of this?"
- Lance: Great question and a couple of the areas we've actually been exploring with some of our research here. One is, if we expose ourselves to heat, we increase something called heat shock protein, and heat shock protein can actually maintain or preserve HIF-1-alpha. And so we've been looking at noble heat strategies such as sauna use, hot water immersion, sauna suits, and really getting the same benefit potentially that we would get if we exposed one to the real thing, in terms of hypoxia.
- Lance: And so that's really appealing because as you mentioned, we may not have easy access to altitude or hypoxia but we have much better access to a sauna, a hot tub, and so we're starting to answer the question, will it work? And it appears the answer to that is

yes. The next question is, well, how do we manage the dose effectively? We tell people, "Well, what's the right exposure? How long, how many days and so forth.

Dave: Is there a timing that works? Do you want to get hot before you exercise, after you exercise or just heck, "We don't need to exercise, just sit in the sun and watch Netflix."

Lance: We've tried a couple of different things, so we've done the exercise with the sauna suit, so exercising with heat and then we've also done exercise and then post exercise, a hot tub.

Dave: I'm guessing that it probably works because that's the most traditional way.

Lance: Yes, both pretty similarly effective.

Dave: Okay, what we do at Upgrade Labs is we actually have intermittent hypoxic training with high intensity intervals where you're breathing air that's been scrubbed of oxygen to induce hypoxia. It's pretty intense, but man, you feel amazing afterwards, stupidly amazing. I have one downstairs at my house that I don't use as often as I probably should, but it's a very meaningful way to manipulate those things.

Dave: And so there's one hack for everyone listening, so maybe after you exercise, hop in the sauna or a hot tub for a little while and there might be some additional benefits that exercise alone wouldn't do for you, okay.

Lance: Absolutely.

Dave: That's cool, I didn't actually know that. That's completely new, I didn't know about the heat shock protein, which we've talked about that on the show before, but I didn't know there was a connection between that and HIF-1-alpha, and I definitely am really intrigued in. For all of you listening who are interested in the biohacking side of things, if you learn how to manipulate VEGF and EPO levels, these aren't EPO's famous... Lance Armstrong and people like that, increasing blood volume.

Dave: But EPO is a hormone that goes up and down and can really affect how you feel, and the same thing with VEGF. These are hackable things that are at the cutting edge of biohacking and you might not know you're doing that when you exercise, but you are. Okay, let's talk about research that you did on the CAR.O.L and for new listeners, the CAR.O.L is a bike. We have one at Upgrade Labs at the Beverly Hilton. I've got one downstairs. My wife uses it, my kids use it, I use it and it's a nine-minute a day thing.

Dave: You ride real slowly, while an AI system is telling you, "Ride even slower. No, you're pedaling too fast." And you're still like, "Why am I even on here?" And all of a sudden, it's like, "Ah, there's a tiger," and then you pedal stupidly for 10 seconds, do you think you're going to die? And then you stop and calm down as fast as you can.

Dave: And it's remarkable, you don't sweat and nine minutes later you're done. You feel good. What's going on in there? Because you did the full clinical validation on this, so why 10

seconds? Why do you have to get your heart rate down the way you do? What's going on in there?

Lance: Interesting question and I break it down from an exercise biochemistry standpoint, right? With a 20-second sprint, you're increasing your energy demand above rest substantially. That's a severe disruption to your homeostasis. And as a result of that, you're putting in motion a variety of upregulation of metabolic pathways that allow you to provide energy that will regenerate ATP so that you can keep sprinting for 20 seconds. And the research is pretty clear that we've identified that minimum time that turns on these pathways, 20 seconds, two bouts a day, and that's sufficient. 20- [crosstalk 00:13:17]

Dave: That's two ten-second [inaudible 00:13:18], right?

Lance: The CAR.O.L protocol we used is two 20-second sprints.

Dave: I could just be misremembering how long it is because I'm usually pedaling like there's a tiger chasing me because that's what the AI is telling you. It probably is two 20 seconds.

Lance: Two 20 seconds.

Dave: Okay, but then it feels like a long time when you're full out as fast as you can. What's the difference between that approach and just hopping on the bike or a treadmill for say, 45 minutes?

Lance: Again, I made the analogy of energy demand, right? For 45 minutes, you're creating an energy demand, but it's gradual, it's slow, it's easy and it's not as much of a perturbation to your body so homeostasis says that the CAR.O.L protocol is... or the sprint interval training is.

Dave: It's about going from baseline to as crazy as possible and back to baseline quickly, and the rate of change is more important than the total volume of exercise?

Lance: Absolutely.

Dave: And this matches what I've been writing about for years since the beginning of my blog, has been this high intensity stuff works better. I used to be a long distance cyclist. There's great value in moving around and walking and all, but for me to lose the hundred pounds that I've lost, it was... food was most important and exercise, which used to get a great deal of attention from me.

Dave: I've spent less time and energy on it because it wasn't giving me results. And the idea is that, okay, how little time can I spend and feel the way I want to look the way I want. Nine minutes seems attractive. But here's my other question. If it's two 20-second things, can I use in four minutes? Why do you need nine minutes?

- Lance: Great question and probably the couple of different answers, one is, you do want to not just jump right into it and there is a warm up built in. You're preparing your cardiovascular system, you're preparing your muscles for that all out sprint and recovering a little bit in between your two 20-second bouts and then having a short warm down as well.
- Lance: But your question's a good one, is there room to shave off even more time with the warm up and cool down. How much value do those have in terms of preventing injury, preventing adverse events and so forth. But probably the traditional reasons why we tell people to warm up and cool down are all a valid here. Can we shorten the workout even further and there's probably some legitimacy to seeking an answer to that question.
- Dave: My friends at CAR.O.L, they might think I'm a bad person, but I will admit that after the second sprint, I stand for 10 more seconds and then I go, "I could cool down on my next phone call instead of going down on the bike," because it's such a gentle cool down anyway. And I figure I'm probably getting most of the benefits, likely or not likely.
- Lance: I would say you're probably getting most of the benefits.
- Dave: Okay.
- Lance: I know that Lana and the kids, they just stay on the whole time. and I do sometimes, but I don't know. I have a lot of stuff I want to do and if I can get an extra game of ping pong in as my cool down, I would do that too, because hey, we all got to live.
- Dave: Okay, we're doing two 20-second sprints. What did you test to determine that this was the equivalent of 45 minutes of exercise or maybe even better? What were the variables that mattered?
- Lance: We had the two groups in our study, the one group that did the CAR.O.L protocol and the other that did the widespread 150 minutes a week, so five days, 30 minutes a day. And so that was the comparator group. And we looked at fitness, we looked at cardiometabolic risk factors, so the lipid profile, the blood pressure, blood glucose and then anthropometrics, waist circumference, body composition. And those were our main dependent variables that we were using to compare CAR.O.L versus the traditional 150 minute per week exercise group.
- Dave: Both groups were doing five days a week?
- Lance: No, the CAR.O.L group started out at just two days a week, and then we gradually progressed it to four days per week for the last couple of weeks of the intervention.
- Dave: Which is better, two days or four days?
- Lance: It was a progression just like we progress any of the... so we didn't compare two days versus three days versus four days, but we looked at an eight-week intervention and we

tried to gradually progress them in both groups. But we've ultimately got them up for the last couple of weeks of the intervention to four days per week.

Dave: Okay, and the final results were equivalent to 45 minutes or to a half hour a day, five days a week, but this was now nine minutes a day, five days a week?

Lance: Nine minutes, four days a week was the maximum [crosstalk 00:18:29] for the CAR.O.L group.

Dave: Okay, so percentage wise, this is about 20% a little bit less than that of the time spent exercising with no shower required?

Lance: Yes, definitely more time efficient and no sweat building up as you would with a, maybe a longer HIIT workout or certainly a longer moderate intensity workout.

Dave: I don't own a Peloton, but the idea of having a highly interactive training thing and all that, it always seems cool, it's a cool idea. And I certainly saw the Peloton ad, which I did not find offensive by the way. But I'm just wondering, if you look at that, is there some other benefits, sweating or something that comes from doing a longer, grinded out on a spin bike thing? Is there a reason to do that if you can get what you needed cardiovascular wise and you're seeing better results in nine minutes than a half hour?

Lance: Yes, so good questions. I think that's a great philosophical question and-

Dave: You've written 130 peer review papers. You're the guy I'm going to ask it. I have no idea what you're going to say, but-

Lance: Right, and so the thing we really run into, we have a community exercise program here and we're seeing hundreds of people come in from the community and they're always inactive and they're struggling to change that behavior. And so the question really, is it easier to change someone's inactivity behavior by saying, go from doing nothing to 30 or 40 minutes a week versus go to nothing to 150 minutes a week or somewhere in between.

Lance: And so there's two different things at play here. There's, are you going to get better physiological responses maybe if you're doing longer intervals or longer continuous training? In some instance, yes, but in some instance, no, you're getting the same benefits with lower or reduced interval training such as CAR.O.L. But the more important consideration is are you going to continue to do it?

Lance: And I think we're going to have a much more easier time and you just said it yourself, you don't even want a warm down. You want to get off and do something else, and so I think that's most people's mindset is, "I'm going to do the minimum," and if the minimum can be effective, I think that's very appealing for researchers and anyone interested in physical activity promotion.

- Dave: It comes down to people probably aren't going to do the half hour a day, five days a week, and the data shows maybe 8% of people exercise at those rates. And everyone else is just saying, "I wanted to go home. I had a commute and I wanted to see my family instead of going and doing that." But most of us can cram nine minutes two or three days a week and that's... it's a pretty minimal ask. Okay.
- Lance: I think another consideration, Dave, is that, you may get people to fit in 150 minutes a week during certain times of the year-
- Dave: Swimsuit season, is that what you're saying?
- Lance: -summer, but maybe when you're not as busy, but if we get into the holiday season where people frequently get very pinched for time, is it appealing to have something such as CAR.O.L to fall back on? And so I think that's another strategy. Not just saying it has to be one or the other, but can it be a combination of both for some people?
- Dave: And I think it oftentimes is and it's different too, "Oh, I'm going to go on a long bike ride with family or with friends. For social reasons, I'm going to go on a hike." You're in shape so you can do that, but you don't have to do that to be in shape is what is what's going on here, okay. Something else that the CAR.O.L does that actually attracted me to try it originally before I had them on the show was I wanted to look at the artificial intelligence.
- Dave: Because they call it the CAR.O.L fit AI, and what they're doing is... they call it the rehab protocol, but they adapt the resistance level based on your weight, how much output you put up before, how tired you are based on some data or another. Did you test that algorithmic approach to increasing resistance and all in the studies that you did?
- Lance: We didn't, no, we didn't specifically study that in terms of what's going into the algorithm. I have the same understanding is what you just described, but what's appealing to that is it's personalized, right? That your 20-second workload is going to be personalized to you.
- Dave: It's the right workload based on your heart rate and weight and all that. Okay, and that's the artificial intelligence side of it, but in the study that you did, it wasn't... they were just doing a fixed amount of resistance for 20 seconds. They're doing a custom amount of resistance to push them to the end.
- Dave: Because I can tell you at the end of the 20 seconds, I'm like, "That tiger is going to get to eat me now because I got nothing left." Because the voice on the headphones that come with it is pretty convincing that there's a tiger chasing you and there's jungle drums and it works, I'll just put it that way and it's actually fun too.
- Lance: It does.
- Dave: All right. But so that was what you tested it and I wanted to be really clear for people who were saying, "I can do interval training at home." Sure, you can hop on any bike

and crank the thing down to spin it and you can't really crank it for 20 seconds without a slow ramp up. And this is from, "You're gently walking through the forest, ah, tiger, run. It's going to kill you."

Dave: And you're standing on the pedals, and it's funny to watch people doing it. I should make a video of my kids doing it, and then all of a sudden, you're red in the face and panting and it is different. And if it wasn't set high enough or if it was set too high, you couldn't do 20 seconds. I've never had it ruin me where I just gave up, and I've never had it get to the point where, "Oh, I could have run another 10 feet away from the tiger."

Dave: Whatever they're doing there seems to be effective and that was what you tested, all right. Talk to me about what you think is going on with glycogen depletion. What's happening in your mitochondria? Why does this type of exercise work?

Lance: Absolutely. When we're doing sprinting to get away from tigers, our most rapid means of energy provision is going to be glycolytic flux, right? We're using muscle glycogen.

Dave: And for people who don't know the glycogen stuff, this is just where your body stores carbs in the body for rapid use?

Lance: It's been demonstrated with ultrasound that a couple of 20-second bouts depletes quite rapidly your muscle glycogen stores. And this is important for a couple of reasons. For training adaptations essentially signals your body after exercise that I need to replenish these stored glycogen or stored carbohydrate. That's why this type of training is great for people that might have trouble with glucose control.

Lance: Maybe prediabetics because it's going to really help upregulate the ability to bring muscle or bring glucose in from the blood to the muscle to restore that carbohydrate, so that's one really important adaptation. And then the relationship between muscle glycogen and mitochondria, which you alluded to, the depletion in muscle glycogen is your body's way of saying, "In the future, if I experience these episodes, I'm not going to be able to maintain it for a long period of time and I'm going to still need to be able to move, and I need to upregulate the ability of my body to make energy in the presence of oxygen."

Lance: And so that happens in the mitochondria and so there's an upregulation of various kinases that activate something called mitochondrial biogenesis, and that gives us a better ability to make ATP in the presence of oxygen and we get higher fitness levels as a result of that.

Dave: I actually have a fetish for mitochondrial biogenesis. It's becoming a more common thing. Yes, I'm guessing that's common in your field as well.

Lance: Absolutely.

- Dave: This is something I wrote about very specifically and headstrong and my book on the brain in mitochondria where, "Hey, if you can do anything possible and there's a bunch of different pathways to cause yourself to grow new mitochondria, it's like getting a bigger battery pack in your Tesla or your iPhone." It really matters. And they're not just batteries, but... And you're saying that the 20-second CAR.O.L protocol is one that drives biogenesis?
- Lance: Yes, so one of the signaling mechanisms that I alluded to, it's AMPK and it's been really clearly shown that that's upregulated maximally with two 20-second sprints. Therefore, adding a third sprint, a fourth sprint, a longer sprint isn't going to upregulate that important signaling molecule that stimulates more mitochondria to a greater extent.
- Lance: And so that's the beauty of the CAR.O.L protocol is its very sound research based from a mechanistic standpoint. The question people might ask is, "Do I need to do more?" You'll get other benefits, but in terms of, if we're focusing on this mitochondria signaling molecule and making more of these, which we're excited about, then you've hit the sweet or optimal spot with this type of training paradigm.
- Dave: Now, there's a study that came out, this was actually after I wrote the Bulletproof Diet, so it's not in there, but it shows that this magic compound called trimethylxanthine, i.e. caffeine, is... also raises AMPK levels, right? And so I do tend to do a Bulletproof coffee before I do my CAR.O.L, and even if it's just a shot of espresso pulled with the clean beans, advisable to do caffeine before hopping into a CAR.O.L session or any high intensity interval training session?
- Lance: Absolutely at the level that you just described.
- Dave: Okay, but you don't need a pre-workout stack that has 400 milligrams of caffeine and ephedrine and is going to pop a vein or anything like that, right? We're talking a hundred milligrams doses?
- Lance: [crosstalk 00:29:36] Absolutely.
- Dave: Okay, that's fascinating and so this idea for me tripling down on mTOR also, we know exercise suppresses mTOR, caffeine or coffee actually suppresses mTOR and fasting suppresses mTOR. And so what I recommend to get the most benefit from exercise and actually, all of the books is exercise [inaudible 00:30:01] after having had coffee, and from my understanding of things, which is pretty deep.
- Dave: If you have some fat in the coffee i.e. Bulletproof, it's not going to affect your glucose at all, and you might get some energy from ketones so it's going to be okay. But then you're doing that in a fasted state, so you've basically suppressed mTOR as much as you can. When you eat after you exercise, your mTOR will come rebounding. You'll get a spike in mTOR, you'll basically recover and build more muscle more quickly, and then you can keep it low later by not eating too much protein. Valid or not valid?

Lance: That's consistent with all the readings that I've done and what we talk about with our graduate students, absolutely.

Dave: Now, when we talked before about AMPK and mitochondrial biogenesis, but what about a mTOR and muscle building using the CAR.O.L idea? There isn't that much muscle that I would think you'd build in these two [inaudible 00:30:57] push really hard. But is this more cardiovascular, heart muscle and conditioning? Is this more mitochondrial conditioning or is there some benefit to muscle just because of testosterone and blood flow and whatever else?

Lance: Yes, that's an interesting question and that's not something we've looked at so I'd-

Dave: It's theoretical.

Lance: [crosstalk 00:31:15] -it'd all be pretty speculative although with... There's some... probably some merit to thinking a spike in insulin growth factor, you're actually... With this high intensity protocol, eliciting some similarities to hypoxia and ischemia because of the high intensity nature. In certain groups as you start getting into older populations, it's maybe not as pronounced, but some spikes in growth hormone. There's probably some speculation that there could be some muscle building properties, depending on some other factors. Again, that's not something though that in a couple of studies we've done that we've looked at.

Dave: It's not a claim you're making. I know that you're teaching people this stuff and that you've spent a decade or more studying all these things, so that means that you can look at something and say, "That probably would work or that's a bad idea, and that you're way more believable than anyone else I've interviewed on these stuff." Okay, so you're saying there's probably some good muscle in this there around mTOR but we don't really know because no one ever quantified it?

Lance: Right.

Dave: Oh, okay. Good, good deal. I've seen different studies looking at different types of high intensity interval training. My earlier books, look, sprint a minute because that's what most of [inaudible 00:32:40] protocol [inaudible 00:32:41]. Run as fast as you can like you're going to die in lay on your back and pant, get up and do it again, two or three times, you're probably good to go.

Dave: But now, we're seeing some franchise outlets and they're doing all stuff that's labeled as HIIT, so what's the difference between lab-based high intensity interval training and what's been the adulterated commercialized versions out there? What are you seeing and do you have concerns or are you supportive of that? What's going on there?

Lance: I think my primary concern with commercialized HIIT is it still tends to be not what HIIT is intended to be, which is time-efficient.

Dave: They're still making it a 45 minute HIIT class when it should be a 10 minute HIIT class, right?

Lance: And so sure, you can get a small segment of the population to do that and do it for a short period of their life and they'll have some remarkable benefits. But back to what we talked about earlier, is that really sustainable from a lifestyle behavior? And absolutely not. That's one of my real concerns, and I think the other concern is these commercialized group classes tend to not be very personalized to the fitness level and health profile of the individual.

Lance: And I think that can be quite risky and people can... We haven't had any adverse events with this short CAR.O.L protocol, two 20-second sprints, and we've actually tested some people that are into their 60s and 70s on the bike, and we're not seeing any problems. And you hear from people that are going to some of these gyms doing the longer interval workouts, having post-exercise low blood pressure, injuring themselves. And those are some of my concerns with what I'm seeing.

Dave: Got it. The way to solve that would be, okay, work with a personal trainer is going to customize a level for you, that just gets to be very expensive. You have to schedule ahead of time versus you have an AI system that does it in your living room. And I will admit that the CAR.O.L is the first exercise bike I've owned that hasn't turned into a coat hanger. So there's that. As an expert in the field, what is your exercise, your personal exercise regimen look like?

Lance: Good question. Putting me on the spot.

Dave: I was just thinking you didn't look that rip. I'm totally kidding. I wasn't thinking that actually.

Lance: It is the time of the year that we were talking about it later, right? Final examinations and-

Dave: Totally, you have a lot-

Lance: Lots of deadlines. Yeah. I mean, I really try to do a mixture. A couple of the comments that you've said earlier in the podcast is exactly what I do. In the summers I do a lot of hiking. We're in the middle of the mountains. I have three boys, so we'll do a lot of longer, gentle hikes, up to higher altitude. But as I am the middle of my semesters and deadlines with grants and projects, I will go to integrating the CAR.O.L bike a couple of days a week and also trying to do some gentle just walks the other days. So I really try to titrate it. And I use the CAR.O.L to allow me to stay healthy and fit when I'm busy, to avoid periods of... to avoid D-training.

Dave: Got it.

Lance: And so that's typically what I try to do. And it's as you get older, and probably same for you, responsibilities with kids and work responsibilities that your time is compromised.

And so I try to use the research that we have available, the instrumentation that we have available to combat that.

Dave: Well, that's some of the most honest talk about exercise possible is like, look, I, I'm an authority in the world on this stuff. I also am a dad is, so putting this exercise ahead of all of your other commitments at times in life, it doesn't make sense for anyone unless you're a pro fitness model or an actor, or someone where the way you look like that is really important. And frankly, half of those people, if you pull their blood work, they're doing it wrong. They're not going to like how they look or feel 10 years from now. But you can have some really nice ripped abs there, but it's short term. So I like that. What about weight bearing stuff? I mean, do you do push-ups? Do you do yoga? Do you go lift heavy things every now and then too, or are you pretty much, this is it, this is what you need right now?

Lance: It's weight bearing is a combination of... and you'll laugh at this. So a true mountain person, you would get about eight to 10 cords of firewood a year have a great wood-burning stove in our log home. And so probably from June through December, that's what I'm doing for my resistance training.

Dave: And that's some serious work. Are you using an axe and are you splitting by hand?

Lance: Yeah, always split by hand.

Dave: Okay.

Lance: It's a good workout. It's a-

Dave: Yeah, it is.

Lance: -10 minutes a day, 15 minutes a day splitting wood and-

Dave: Stacking cords, all good.

Lance: -and I do it summer, do it throughout the fall and then it's a periodize my training unintentionally. I don't do much resistance training but skied in the winter.

Dave: Okay, so you mostly move and you do some cardio. Okay. I like that. And this is after writing 130 papers on this or contributing to them, and studying it and teaching it. This is where you ended up. That's actually really cool. Talking about inflammatory markers that you've seen in the studies you've done or in other research you've done, exercise can be highly inflammatory. In fact, that's why it works to a certain extent. What happens to inflammation when you're using these short, brief CAR.O.L style intervals?

Lance: It's great question. It's not a measure that we had in either of our projects, so can't speak directly to that the findings with our projects. However, from the literature and that the literature on other sprint interval training, that's probably one of the valuable things about keeping it brief and keeping the bouts to a minimum, is that you're

producing a good amount of inflammation that then is going to stimulate some of those adaptations we want to see, but not going overboard and not creating a chronic inflammatory state, which then starts to become problematic for disease reasons as well as over-training.

Dave: Of the people who exercise four or five times a week, what percentage of them do you think are likely to be over-training?

Lance: We've done some cortisol measures on our athletes here and probably 85% to 90% of them from that cortisol measure are in an overreaching or over-trained state.

Dave: 80 to 90% of them? And I'm so happy you said that. I have experienced the same thing. I used to do more coaching for high performance cognitive and executive stuff than I have time to do now, but I'd see these CEOs and they're saying, "Oh yeah, I'm trained to go do the Kona iron man and here's my regimen." And I'm like, "Hold on. You just got back from Japan." Like, "I landed in Japan and I went for a two-hour run." And I'm like, "When do you recover here?" But then you say, "How's your sleep? How's your testosterone?" "Yeah, my libido's shot, my sleep is not good. But I mean look at me, I'm 9% body fat and my company's going to go public." And you find out though, when you get to know a little bit, like they're dragging ass, which is a technical term.

Dave: And I know I got to that state when I said I'm going to lose my a hundred pounds. I worked at an hour and a half a day, six days a week, halfway tough cardio, come hell or high water. I don't care if I'm sick, I'm going. I didn't lose the weight because I had a cortisol problem that I developed from doing it. Right? So you're seeing the same thing. It's an endemic problem and it's not a call to exercise less, or maybe it is, you still have to move. Right?

Dave: And just to do the kind of exercise that works. And you're saying that at least not you're not saying in general, but the studies that you did and these weren't says CAR.O.L paid for, they're American Council on Exercise to find efficient things, you just use CAR.O.L as the tech. Just to be really clear, like this wasn't a paid research thing. Well it was paid, but it wasn't paid by the people who created the tech. So you're saying that that wasn't generating over training even when you got them up to four times a week?

Lance: No, rarely well tolerated. And again, RPE levels of what you would see once they got used to the, the protocol, RPE levels, what you would see when someone does moderate to maybe a little bit vigorous intensity exercise, somewhat hard, so quite interesting. Even though they're all out when they finish the workout, they're reporting, "Yeah, that wasn't all out in terms of I'm exhausted."

Dave: So no one's ever going to bonk on this.

Lance: And then just the training responsiveness across a variety of variables that you don't see when you are over-trained, because inflammatory markers. If it's chronic inflammation interferes with training responsiveness. And so, again, we didn't measure in this study cortisol, but usually when you see cortisol elevated or some of the interleukin

inflammatory markers elevated, it attends to really blunt training responsiveness because things like you mentioned with your CEO sleep and other things get interfered with, and it just it's a vicious cycle that you don't respond favorably.

Dave: Okay. So you didn't measure it, but because they responded to the training, you can infer they probably didn't have a cortisol problem.

Lance: Absolutely.

Dave: Okay. I got it. That seems pretty cool. What about calories burned? I keep talking to people from the 1970s who say, "But what about Newton's law and conservation of energy, it's calories in, calories out and all that." Did you look at calories burned or fat loss and things like that, and did it matter? What'd you find?

Lance: Yeah, good question. And something is probably the next step. So we got some preliminary data on calorie certainly during the actual session, but then afterwards or the EPOC phenomenon and-

Dave: What's the EPOC phenomenon?

Lance: So the EPOC stands for excess post-exercise oxygen consumption. And we know when we exercise, we exercise severely, we disrupt a variety of our homeostatic parameters. So our resting heart rate, our resting ventilation, our hormone levels, our sympathetic nervous system. And those don't just go back to resting values, resting values immediately post exercise, it persists and all of these things. So increased ventilation, increased heart rate to replenish glycogen stores, to rebuild muscle takes oxygen. And so we're consuming oxygen at a higher level than we were prior to exercise or we haven't increased EPOC. We're burning more calories. Right? So EPOC is also referred to sort of more in a lay term, afterburn.

Dave: Got it. So the idea is you had to repair and recover, so it took more oxygen, thus it took more calories. Because if you're burning oxygen, you're also burning food calories or fat calories, like they came from somewhere.

Lance: Absolutely. And that's where we're not just getting the benefit from the two 22nd sprints and it's all exclusively during that timeframe. It's resulting in a physiological Maloo in our body that burns more calories for some of the literature is saying 12 hours later, 24 hours later. And as you just alluded to, that's going to benefit weight management. That's going to benefit your lipid profile because those excess calories you're burning are going to most likely be fats. It's you're replenishing your glycogen stores so you're using more glucose. So that's if you're a little high on your blood glucose level, it's going to benefit that.

Lance: So the EPOC phenomenon is something that's really important consideration for what's at play with the CAR.O.L protocol and something that we just looked at a very short timeframe after exercise and EPOC was probably two to three times higher right after exercise than it was compared to moderate intensity training.

Dave: Wow. So if you did nine minutes on CAR.O.L, you could eat a donut and it would hurt you less than if you did 45 minutes of a normal bike and ate a donut? Tell me it's true. That's what I heard there.

Lance: Yes.

Dave: It is? I'm not saying a donut's good, I don't eat donuts but I'm just like because you actually are having higher post exercise oxygen from two 22nd sprints, then that's cheating. I love it. Okay.

Lance: Absolutely. Absolutely.

Dave: I could see how uncomfortable you are with the donut conversation there. These are weighted donuts made of a paleo flour. Yeah, yeah.

Lance: There we go. All right. Something else, a friend of mine who is a long-term spin instructor for years and multiple classes a day kind of thing. She had both hips replaced before she was 40, I think 45, early 40s, and I've wondered is many, many, many hours a day. And I'm not saying it's spin training, it's for the average person, this is an instructor who pushed herself really hard. Let me put it another way. What concern do you have for wear and tear for the population who's doing 30 to 30 minutes to an hour a day, many days a week over the course of decades.

Lance: So certainly, the high-intensity nature of doing exercise, doing high intensity exercise for decades will eventually catch up with you. And so I think you have to have more modest or manageable ways of approaching your overall training paradigm. And so, one way is people who are lifetime devoted to high intensity exercise, they're going to really struggle with overuse injuries eventually as they get older. And so trying to find an alternative to not compromise the health benefits but allow for less stress on hips, knees and so forth.

Dave: So this might be more sustainable. And I just wrote Super Human, my book on living to Elisa 180, and I'd rather not have new knees and new hips inserted when I'm 90. If I can do things now that are giving me the metabolic ability to live that long and are not causing you to become more cyborg than I already am, it seems like a good strategy. Which is one of the reasons I'm interested in not over-training or not overstressing parts of the body but not under stressing them either. Because if you do that, they turn to mush-

Lance: Absolutely.

Dave: -and you don't want that either. Osteoporosis is no person's friend. What about cardiac safety with these? I mean, I know when we deal with some of the really intense CrossFit, but you take someone who's deconditioned, you throw them in and, "Hey, do the wad," they're sore for two weeks and they can even get that rhabdomyolysis where you clog your kidneys with broken down muscle tissue, which is not a good thing. And that's not

to pick on CrossFit in that any sort of heavy intense lifting from [inaudible 00:50:29], there's no conditioning. There's some small risk of that.

Dave: But in other words you can go too far. I just wonder for this kind of thing, in terms of overexerting from a cardiac perspective or any other, did you hear any of that or did you see any of that?

Lance: Overall, the literature's fairly clear that hit done properly, and so the traditional hit that began to emerge maybe 10 or 15 years ago, the four by four model, even that a higher volume hit, there wasn't a more pronounced risk of cardiovascular events compared to moderate intensity exercise. And so we're now looking at not the traditional higher volume hit, but a lower volume and a personalized volume of hit. So that's going in a more conservative direction from a risk of cardiac events standpoint.

Dave: So lower volume and the intensity that's customized. And I know in the CAR.O.L example, specifically they're looking at your heart rate because you're holding onto the bike, so they're monitoring it. But if you were to try to do a high intensity interval training without cardiac monitoring, it might be a higher risk. But it's probably not that big of a risk unless you take someone who's 50 pounds overweight and hasn't exercised, and say, "Go run the sprint for a minute." Drill instructor style, there probably is some cardiac risk room, something like that.

Lance: Yeah, probably not taking someone who hasn't exercised for 30 years and has known cardiac disease, and as a starting point maybe doing CAR.O.L.

Dave: Okay. There's something like that. Okay. It's gentle enough.

Lance: A build-up to that. But, again, we had some older individuals and individuals with risk factors and the key is, again, and it's come up a couple times, is the customized resistance is so critical. So a lot of people think of interval training, interval training on a bike. We're not talking about someone who's pumping a thousand Watts or 800 Watts. We're talking about for, let's say, a 67-year-old grandma. It could be 190, 220 Watts. So it's customized so that it's also adjusting it based on their fatigue as well. And I think that's so important to emphasize the personalized nature of it versus what I think in a lot of people's heads is what's going to happen during interval training. They're doing a workload that a high level athlete would be doing, and that's just not the case.

Dave: Okay. They don't have to do that.

Lance: And let me tell you one other interesting thing we found, Dave, with regards to risk. So we measured blood pressure, right? So we measured blood pressure, maximal blood pressure, and the maximal blood pressure during the sprints never exceeded a blood pressure value that is considered to be a contraindication to stress testing in a hospital or a lab setting.

Dave: Okay. So people, even in the end of the 22nd sprints, they're not doing anything that's risky from a blood pressure perspective. Okay. So it's phenomenally safe and you had

people at different ages and all that stuff. It was more effective than spending more time doing more unpleasant styles of exercise. This makes me happy, all that stuff. What do you think about the people say, "I've decided I'm going to get healthy, I'm going to run a marathon," and then they start training for that. Good strategy. Bad strategy.

Lance: I generally discourage people from having that goal, is that's the first thing they're going to reach for. Let's start with a 5K or a 10 K.

Dave: There you go. I always laugh and by the way, I fully supported it. People say, "I want to run a marathon to prove that I can do it and I want to do it once every 10 years or something." Just more power to you. Like that was an accomplishment. I do have concerns that the first person who ran a marathon died from doing it, which is why we celebrate them and I have not seen evidence that, for the vast majority of people, that appears to be the healthiest exercise option for them to live a long time and feel good all the time. And so you could say, "Then you're anti cardio." It's like no, there's a cardiovascular stuff's important.

Dave: There has to be a middle answer where too much is bad and too little is bad. And I'm just seeking that middle. And it seems like you've done some pretty good science here on finding what's going to work when you're saying three intervals is less effective than two. Okay. I'm pretty excited about that. And CAR.O.L, when they asked you to come on or ask me to have you come on, I said, "All right, I want spend a really knows what's going on." It was not commercially motivated here but someone who's science motivated, you've definitely convinced me more. I won't say more than they were already committed because I tried the thing and then they came on the show and talked about it.

Dave: But you've really answered some questions that I didn't know the answers to about this idea. Is there anything else that you think is a major misconception about exercise that we haven't covered today? Just if you could sit down to hundreds of thousands of people, what you're doing right now and say, "Look, this is what you have wrong about exercise." What would you say?

Lance: I think what we've had wrong, and I think I maybe briefly touched on it, but it's good to maybe emphasize even further. I think what we've had wrong for a long time, and certainly scientists have had it wrong. And I think individuals in the health and fitness industry, and even medical community is this notion that more is better. And we can't even get, you said it, 8% of the population to do 150 minutes per week, so why are we spending so much time researching in that domain, making public health recommendations in that domain if so few people are achieving that.

Lance: And so I think that the focus on going to the interval training and also to the lower volume and in interval training is very important. It's as we've discussed, there's great evidence to support it just from basic research to the mechanisms that support it. And I also think, maybe just to add one other thought, is the personalized nature of any exercise is so critical. And for too long, a one-size-fits-all approach has been applied and I think that's not helped with the 8% statistic.

- Dave: I very much like that. Just like with food, we're not all the same. The diet that works for one person might not work for another, but there's some basic rules around it. Don't eat too much, don't eat too often, that do work for everyone. But the composition is going to have to be based on your genetics and who you are, and what you're doing and what else is going on in your life. And it makes sense, exercise would be the same way. So telling everyone you get the same size meal as the other person, even though one person just exercised and has been fasting for a day, and weighs 250 pounds made out of muscle, they might want three meals. And that's okay. Right.
- Dave: So exercise goes along the same way and I do believe people tend to forget that. And I appreciate you calling that out or the customization matters. And I, because I'm lazy, I like the idea of an artificial intelligence customizing things for me because I don't have to do the work because I'm lazy. And if I could exercise less, and I could think less, I'm happy to do that because it frees up capacity for other thinking or other things, which is cool. I really appreciate you coming on the show and I'm going to ask you something that is maybe less exercise-related but I just wrote my big book on anti-aging, and I've got some big goals there.
- Dave: How long do you think you can live given all the things you know about exercise and some about nutrition too that's part of that whole thing. Like what's your maximum lifespan that you think is achievable, it might even hit?
- Lance: Ooh, interesting question. I'm a big fan of the concept of a Paleolithic lifestyle, removing some factors. And I think with modern medicine and with adherence to some of these things we know, 140.
- Dave: Oh, look at you. All right. I love it. 140, because we have modern medicine, right? And we keep looking backwards, people would make it to a hundred now. We didn't have antibiotics when they were born, like it's a completely different world now. Wow. All right. 140 that's a great number from a guy who's really dug in on house and physiology works, which is awesome. Well, thanks for coming on the show. I know that your research people can certainly Google Lance Dalleck, D-A-L-L-E-C-K and find all the papers that you're in and the CAR.O.L technology that you ran those two studies on. Is at CAROLfitai.com and that is a bike that I have downstairs and that I actually use based on the last interview with CAR.O.L. So that's the big URL to go to. Anywhere else in particular people should go to find out about your research in particular?
- Lance: They can go to western.edu and type in the High Altitude Exercise Physiology Program. We've got lots of good information about the projects that we have ongoing here on our website.
- Dave: Ah, beautiful. In fact, for some of the hypoxia related stuff we talked about as well, I think you probably have some good info there. Okay, so that's western.edu.
- Lance: Correct.

Dave: Okay, awesome. Lance, this has been a fascinating, and we went to all sorts of places. I didn't think we'd go. We've got to talk about vet Jeff and EPO, and I did not also know that doing three intervals was worse than two on this, and all of this is just making me happy.

Lance: Thanks for having me, Dave.

Dave: If you liked today's episode, you know what to do, go through an exercise less already. Okay. Maybe not, go out there and move around anyway and do some intervals, maybe some really fast ones, and not for too long. Do consider the CAR.O.L bike if that fits in in your kind of lifestyle, because I think it's actually a really cool innovation. So I'm recommending it. And if you haven't read any of the books about mitochondria, you want to know more about, we talked about amputation and all that. Check out Headstrong. It's a really good book. Or check out Super Human, which puts it all together and how you can live a lot longer on my most recent book and what all people are saying is the best book. And whatever you do, if you read a book, leave a review. I am thanking you in advance.