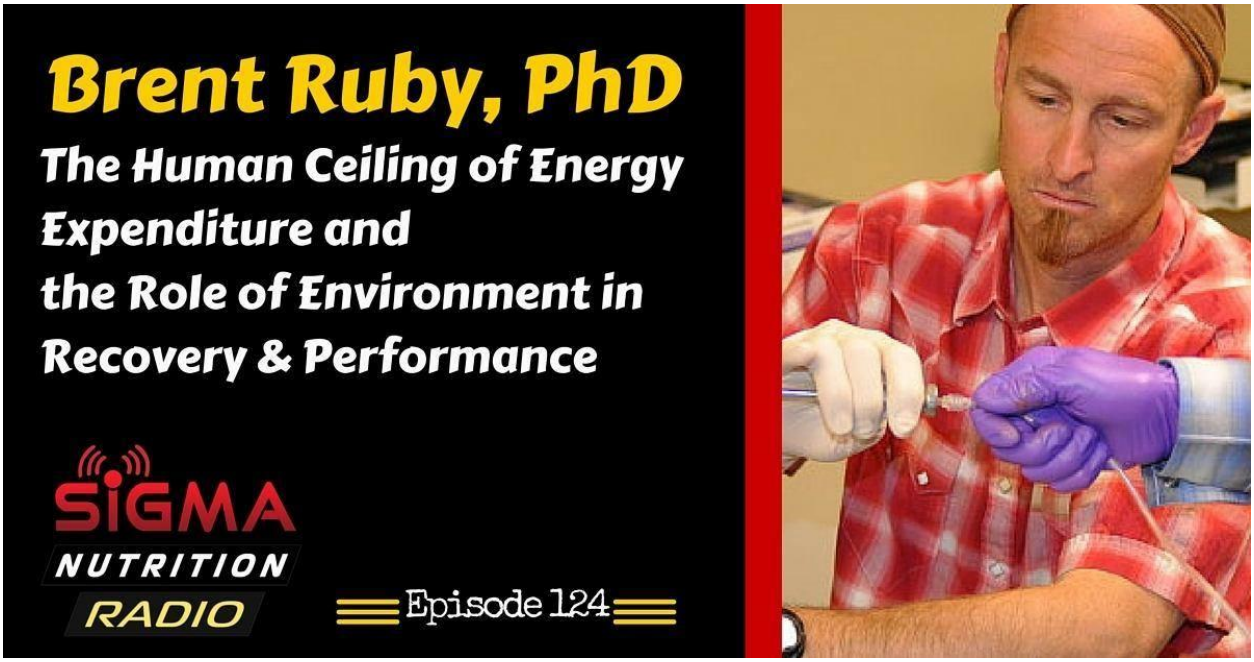

Danny Lennon: Hello and welcome to Sigma Nutrition Radio, the podcast that brings you evidence-based discussions with the world's leading researchers in fields related to nutrition and performance. I am your host, Danny Lennon, and you are listening to Episode 124, and today I'm absolutely pumped to have Brent Ruby from the University of Montana's Center for Work Physiology and Exercise Metabolism on the show. Brent is just such an awesome guy. Not only is he in charge of a lab that is doing fascinating work as you're about to hear, but he really tries to push the envelope in terms of asking interesting research questions and thinking outside the box when it comes to study design. And he's big on not only relying on nice, clean lab data that we get in very controlled but artificial settings but also trying to attempt to see what happens when you take these same participants or athletes and monitor them in various different environments very similar to the ones they're actually facing in competition or maybe actually doing it during competition. He's just a super-interesting guy and quite brilliant at what he does, and just a really cool dude in general.

The show notes to this episode are going to be at SigmaNutrition.com/episode124, and if you go there you'll be able to get links to all the research papers we mention today, any other resources that Brent may mention on today's podcast, and you'll also be able to get a transcript to not only this episode but previous podcast episodes as well, all for free which will be delivered to your inbox as a PDF, and you can

just do that over at that show notes page I just mentioned. So let's get down into Episode 124.

Brent, welcome to the show. How are you doing today?

Brent Ruby: Doing very well, thank you.

Danny Lennon: Now, it's really good to have you on and I'm actually really excited to get into this whole conversation because I've just found some of your work so fascinating reading through it and there are so many topics that I want to get into. But maybe just as a means of shaping this whole conversation first for people, could you perhaps bring us through your background and the journey that got you so passionate about the stuff you now look at in research?

Brent Ruby: Yeah. Well, I was an undergrad student in Seattle in a small university called Seattle Pacific University when I discovered the field of exercise science quite by mistake. I was like so many interested in pre-physical therapy and pre-medical sciences or premed, and then I took one exercise science course and that converted me. So that was a long time ago, and then I did my master's and doctoral studies at the University of New Mexico and, much to my adviser's displeasure, I kind of ran off on my own path and worked with some docs at the clinical research center there and got really interested in metabolism and some sex differences work and some auxiliary effects that maybe some of these reproductive hormones might have on the muscle and so on and so forth. So from the very beginning, I feel like I've been somewhat of a maverick in terms of paving my own path and being passionate about paving my own path.

Danny Lennon: Right.

Brent Ruby: I mean, that comes with its own bumps and bruises of course because reviewers want you to fall in line with their train of thought, colleagues want you to fall in line with their train of thought, skeptics are always all over the place, so I haven't had the friendliest of relationships with reviewers over the last several years, like 25 years. It's gotten better.

Danny Lennon: And that's definitely something I want to dig into a bit later on. I think this whole idea of trying to go by good science of remaining and critical whilst at the same time having to maybe from within the scientific communities almost pull to come back to convention, but we'll maybe circle back to that.

Brent Ruby: You bet.

Danny Lennon: Maybe first we can talk about your lab specifically. What are the main areas of research that you and your colleagues are focusing on right now and have done in the past?

Brent Ruby: Well, ever since I came to the University of Montana, which it seems like I just blinked my eyes and all that time has sped by, I came to the University of Montana in 1994 where there really was no lab. There was barely an old locker room space available with a Beckman metabolic system that had to have a program cart inserted in it to run it. So over the years I've kind of created our own unique space and our own Regents-approved center called the Montana Center for Work Physiology and Exercise Metabolism, and our focus primarily is on the interaction that the human deals with when you slam together varied ambient environmental conditions with the work that the muscle is required to do. So what's the interplay between the environment, the nutrient, the nutritional intake, the energy expenditure, the substrate oxidation, the muscle recovery issues? How does that all fit together? I really think the field has done a poor job historically—I mean, they've done a fantastic job at maintaining this wicked high level of internal validity in all these different studies; oftentimes, the nutritional recommendations, the training recommendations are based on studies that are collected in a climate-controlled laboratory environment which is so far distant from the working world of the occupational athlete or the elite athlete, and so we bring the environment into that picture and it changes things radically. What you recommend somebody to consume, if you say just off the cuff it's 60 grams of carbohydrate per hour for an endurance athlete, well, no, I don't belie that. When the environment is something you're not used to or acclimated or acclimatized to, that recommendation is thrown out the window.

Danny Lennon: That's a really important thing and I think we'll definitely touch on that because a number of the papers you've authored have looked at that whole area, particularly around glycogen restoration, for one example, and how the environment affects that, but first when we talk about some of those different areas that your work has looked at, maybe if we look at the area of the energy demands particularly on longer-duration endurance-type work where people are really pushing the limits of how much energy they're expending, could you maybe just explain for folks who aren't familiar with this assessment in research how do we actually go about assessing energy expenditure in the lab and maybe for example what

exactly are stable isotope traces, etc., etc.? How can we get an idea of how much energy a human is actually expending?

Brent Ruby: It's funny, today, in today's technology and today's basic undergrad exercise physiology course and lab courses, it's a measure that people just completely take for granted. The use of indirect calorimetry is exceptional in being able to quantify human energy expenditure. Unfortunately, you have to be tethered to a machine and the expired gases are analyzed. It does a great job of giving you the numbers. The portable systems are fine. I don't really care for them that much because they're quite fragile and—but that's basically how you would pull it off in the lab. It's a whole different story when you run outside into the forest and decide that you want to measure the energy expenditure of the nation's elite wildland fire force. You can't expect them to carry a metabolic card or collect bags on them during their work. They're very much a free-range elite occupational athlete and you have to accommodate their work environment with a different methodology.

So years ago we started using a couple of different stable isotopes which have become common in the measure of human energy expenditure or total energy expenditure, and the two tracers, one's a deuterated water and the other is an O-18 water, both isotopes are delivered orally and you can track the change in isotope enrichment through serial collections of urine, which they're going to get rid of anyway. So we have become well-known for chasing fire crews and lots of other unique subjects around getting urine samples at different time points over three days, five days, seven days, whatever. The nice thing about that technique is it's very hands-off. It's noninvasive. You don't have to really pay particular attention to what the subjects are doing. It's just simple urine collection and then subsequent analysis and it does give you a really solid picture of the total energy demand over that measurement window.

Danny Lennon: So with that idea, when we're talking about energy expenditure, one of the really cool things about a lot of your work is that you've worked with a lot of populations that are specifically people who are going to have extremely high energy expenditures. And actually one of the quotes, as an aside, that I came across I think attributed to you is, "I always say how boring life would be if you only expended 2000 calories a day," and I just kind of love that idea.

Brent Ruby: [Chuckles]

Danny Lennon: So you mentioned there, for example, the firefighters. You've worked with military guys, high-level endurance athletes, people with huge energy expenditures. So when we're talking about just how much energy these types of folks can expend, how high have you seen this actually get in some of the work you've done?

Brent Ruby: There's really twofold measures in this technique that we've looked at and that is certainly the total energy expenditure and kcals per day – kcals per 24 hours, and wildland firefighters, I mean, they're really working hard for perhaps 10 to 14 days in a row and their energy expenditures top out…well, the range is huge, you can imagine – 3500 kcals per day all the way up to maybe 7000 kcals per day.

Danny Lennon: Wow. Right.

Brent Ruby: And so it becomes an enormous challenge trying to feed them given that that's their work-oriented energy expenditures, not the easiest thing to ensure that they're going to get enough calories over the course of that 14-day work shift. In some of the other examples like an iron man, iron man athletes fall right around about 9000 kcals for the race itself at the Western States 100, which is kind of the granddaddy of all ultramarathons. A 100-mile mountain race in Northern California, some of those athletes, almost all the…we studied 10 persons in that race, both males and females—and these are average finishers. These are not the elite elites. These are average persons that put in the training volume to get it done and they're in the range of 16,000 to 19,000 kcals in a 24-hour window.

Danny Lennon: Wow. Wow, that is crazy.

Brent Ruby: So the numbers, I love those numbers so much because I always try to link those back to our early ancestors and early humans and there's really no rationale for why an early human would have that capacity. So it is fascinating to put a gold standard measure into those events. I mean, you could use ACSM equations and running equations and come up with estimates, but that's just a mathematical number as opposed to a more direct measure using this gold standard technique. That's pretty exciting to get those numbers.

Danny Lennon: For sure. So if we're talking about then people who are not necessarily at the elite of that competition, that are kind of maybe middle of the pack, they're able to get up to energy expenditures of like 16,000 to 19,000 calories a day, just keeping in line with what you mentioned about the kind of evolutionary aspect then, what do you think that kind of should tell

us then about the capacity of the human body in general? Like what is this ability to be able to have these huge energy expenditures? Does that tell us anything interesting that maybe is easy to overlook?

Brent Ruby: Oh, yeah, I really think. I think there's a really unique poetic connection to that number and the uniqueness that is the human. It really demonstrates to me that we are put together for physical activity. It's ingrained so deeply with down to the genes and our muscles that we're preprogrammed to have to do that. It's a requirement. And we see that, certainly when you look at the evidence for physical activity and disease, you can reduce the risk for almost…there are so many diseases that are physical-activity-oriented or without physical activity the disease is much more likely to run its course. I think those numbers just strongly demonstrate that physical activity is a human requirement.

And you know what's so interesting nowadays is, in order to tap into that requirement, the strategy is getting more and more simulated, if that makes any sense. I mean, instead of hiking over a mountain, we decide to walk up a mechanical staircase in a gym listening to Beyoncé so that we can just get over the top of the hill. Everything is becoming more and more artificial so that we can get at sort of that fix, if that makes sense.

Danny Lennon: A hundred percent, and it's almost like this any type of activity now is becoming something that is formally having to be scheduled as an exercise bout as opposed to just being this natural activity that's done throughout the day in all these different environments.

Brent Ruby: Right.

Danny Lennon: It's become a thing that you schedule in to do a set amount of this activity, and then the rest of the time is the norm becomes sedentary behavior, right?

Brent Ruby: Exactly, that's a great perspective.

Danny Lennon: Maybe let's start digging into a couple of specific studies because I just found them absolutely fascinating to read. I think one was maybe from back 2007 or 2008 and I think it looked at a 2000-mile ride actually, like 100 miles per day over three weeks, which I thought it's just amazing to read, and you're taking time trial performance analysis every three days or so.

Brent Ruby: Yeah.

Danny Lennon: Can you maybe just go through that for people? Can you just talk through what initially was the aim to examine there, how you went about setting up and what the kind of final results told you at least about what was going on?

Brent Ruby: Yeah, I have tremendous memories of that study. I rode every other day with the participants and we traded off to ride with them, but we were coordinating the study the whole time as well and managing the efforts in the field. So that was one of the most aggressive field studies we have ever done, and we've kind of become well-known for our aggressive field studies over the years but that was certainly the biggest. So it was a 21-day overtraining type of a study. The study design was bent on increasing their training volume by about 400%. So they're riding at between 100 to 120 miles a day for 21 days and we were collecting samples and doing assessments the whole way through. At the very first day of the event and the last day of the event and then in the midpoint of the event, we took muscle samples to look at acute alterations from the day and to look at markers of adaptation that might crop up as a result of putting in 21 days worth of hard work. So really the question was based on, can we overtrain these guys and what are these symptoms of overtraining that people always swear by and promote in the literature? Are you guys demonstrating that or, because we're putting them in this unique situation, are they not going to demonstrate that?

Any time you have an overtraining approach, you can't rely on blood, saliva, any of those metrics. Those are symptoms. You really have to look at the underlying performance. Is the performance negatively affected? If it is, yeah. Then, if it's partnered up with some of those metrics, maybe those metrics'll tell you something. But we could hardly overtrain these guys. We're increasing their training volume by 400% and we couldn't—I mean, occasionally we'd see a symptom here or there, in the salivary markers, and of course these are all after the fact.

But they did a time trial which we called the hour of power. They did a time trial every third day. They had breakfast, they warmed up, and they started off their hundred-mile day with a 60-minute hour of power and really, if anything, they started to get better by the end of the 21 days. So it was an enormous training volume in that short period of time and I think just by removing some of their other life stressors, I think that is what allowed them to accommodate this enormous volume. And so in those two studies we sort of challenged some of the classic markers of overtraining

and we also show some of the muscle enzyme adaptations that crop up as a result of putting in an epic 21-day window.

Danny Lennon: Yeah, I think there were a couple of really interesting things in that – number one, that oftentimes it's probably easy to jump to using these proxy measures for many different things, but in this case, these different proxy measures for overtraining, and maybe conflating that with actual overtraining, but if we don't see a performance decrement then it maybe doesn't matter as much.

Brent Ruby: Exactly.

Danny Lennon: But then perhaps the really interesting thing is the fact that you mentioned that they had these decreased stressors from life that obviously were being monitored at the study. So it could be a fact that they just had a better capacity to recover. So do you think then it's often the case when people feel they're overtraining, it's probably more a case of just simply under-recovering as opposed to just the training being too hard?

Brent Ruby: Yeah, I think that, you know, a lot of these athletes, especially college athletes and probably some professionals, we don't work with a lot of those guys, they're pretty hands-off, but you think about the other life stressors in a college athlete and the physical activity, that is, their training sessions, that's probably the most peaceful time in their whole day.

Danny Lennon: Right, yeah.

Brent Ruby: The rest of the time is like, "Oh crap, I got to think about this schedule. Not working well with my roommate. I got this relationship issue. I got to have a part-time job." All those other stressors add up and they compound or they build on top of the physical stress of the workout and then the person starts to break down mentally or demonstrate some of these blood values or they get an upper respiratory tract infection or whatever. But the guys in that ride, none of them really got sick, none of them really—I mean, we had our few outbursts and whatever, we certainly had our share of flat tires and a few mechanical problems, but there's a YouTube link that's like a little 45-minute documentary from that study that I could certainly share with you…

Danny Lennon: Yeah, for sure. Yeah, and I'll link up to that in the show notes for people listening. I'll find that and I'll put that in the show notes so you can check that out. One thing that kind of triggers off my head when we're talking about some of these studies because they're so interesting and so create in

their design and they're looking at these situations that are impossible to recreate in a lab, really, so how do we kind of balance the idea of this often pressing need people have for really highly controlled studies that are obviously like a gold standard can tell us a lot because they're controlling so many variables versus being able to learn things from these more creative interesting studies like this that can maybe translate directly to what people are doing but maybe just by their nature is going to be impossible to be as well-controlled? Where is that balance or what thing should people bear in mind when we're looking at this kind of different disconnect between those?

Brent Ruby: That is a great comment question series because when a young investigator begins their career, one of the first courses they take is a research design course or basic statistics and research design, research methodology, and one of the first things that they're faced with or presented with is threats to internal validity. What are the things that can jack up my study design? What are external factors that can bear down on my measurements that I'm so tightly…everything's calibrated and controlled and this and that? Are there things that can affect the quality of my results? And so the focus becomes so strongly leveraged towards controlling internal validity that external validity becomes just a passing thought. In fact, even in most of those classes, they're like, "Oh, internal validity, got to control this and this and this. Oh, and then there's also external validity." That's the degree to which you can generalize your results outside of the parameters of this tightly controlled study, and we wear lab coats, so we need to have high levels of internal validity at all costs. At the same time, then you're turning around and you're telling the athlete or the coach, "This is what we found in the study. You need to do this. You need to eat this way when you recover or you're going to hell on a grease pole," or, "You need to do this. This is the mandatory dose per hour that you need to stick with," and it's based on results and it's based on these controlled studies. But as soon as you focus your lenses towards managing external validity, so many of the great papers that a lot of our theories, thoughts and practices are based on as clinicians or coaches, a lot of those recommendations drop to the wayside because they're not practical given the environmental stress, could be the temperature, could be the altitude, whatever, and so we have just pounded it into reviewers that—and they love hitting back and at some points it feels like Rocky I you're going back and forth with a reviewer and the reviewer… One of the reviewer comments in this cycling study said, "I don't understand why

you didn't do the whole study in the lab. You could have controlled [00:25:45] so much better."

Danny Lennon: Wow.

Brent Ruby: And at that point I was like, "I'm done. I need to talk to the editor because this is a ridiculous comment." They have missed the point so many times in some of our aggressive field studies, but we really hold strong to the notion that what we do out in the field teaches us how to design studies better when we do have to go back into the lab, and so there should be this pass-through or a tradeoff. You can't have one all the time and you can't have the other all the time. You have to have a combination. And that's sort of the model that we really stuck with over the years, is that we learn more out in the field than we could if we conducted five other studies in the lab. That's a controversial way of thinking but it has served us well when we hand off results to the end users that we play with, which are military forces and these occupational athletes like the fire crews and other ultra-athletes, so.

Danny Lennon: Right, and I think that's a really important point that when we're considering that type of population, whether it be an athlete or military personnel that, again, if we have a really tightly controlled study that shows a benefit for some marker, for example, if that doesn't actually translate to a real-life performance benefit, then kind of it's like, what's the point, right? Where you can actually measure that with these field studies that are a better simulation of what's going on.

Brent Ruby: Absolutely.

Danny Lennon: You mentioned in there a quick point around recovery strategies or recovery nutrition and it's certainly an area where there's a lot of conventional thinking that hopefully is getting challenged. So if we maybe switch to recovery strategies in general, I really enjoyed reading some of your work on the role of the environment that we're placed on and how that affects the recovery phase, which you mentioned right at the top of the show, and I'd like to talk specifically about the study that investigated the effects of a hot versus I think room temperature recovery environment on a number of different things, I think glycogen resynthesis being one. But before we get to that, just as again some background context for people who aren't as familiar, what other factors do we already know about from research that will affect glycogen resynthesis rates? Because it's not this one person has this one set rate. We know different things affect it, right?

Brent Ruby: Oh yeah. It seems like every glycogen recovery study promotes itself as a unique new finding and we got to realize this stuff's been going on since man first walked on the moon in terms of muscle recovery and glycogen and with some of the early work of David Costill. So recovery happens no matter what. I think the emphasis lately within the popular press and in others is like there's a group, a large group of people who thinks, "Hmm, I can make money off this concept. We should market chocolate milk. We should market this product or we should market that product," and it's like all those products probably work just like every diet works, but I don't think there is no magic bullet. Why we wanted to throw the environmental wrench in is because most of the time athletes don't recover in an air-conditioned lab. They recover in different climates depending on the season, depending on the geographic location or where they are in the world. And so we started with altering just simply the ambient temperature within the room in this repeated measures, this crossover design. So the subjects in this study performed two different trials but they were both glycogen-depleted in the lab and then under the same lab conditions so you could get uniform glycogen depletion, which we've shown over and over and over in these studies. Then, we transitioned them to a recovery environment, which was either a warm ambient condition or the air-conditioned lab condition, took samples at two hours post, and then again four hours post, which is a little bit aggressive but we wanted to answer a more precise question than just our common four-hour post exercise sample. And by two hours there was really no difference between the two recovery environments, but by four hours when they were forced to recover in the hotter environment they were not capturing as much muscle glycogen compared to the lab environment.

So that really prompted us to think, "Huh, is this only temperature or is this only heat? What if we put a person in a cold environment? What if we put them in a high-altitude environment?" And so we played around with all these different environmental conditions and it's funny, it's perhaps bold to say but I've said it over and over that the environment that the individual and the muscle recovers in, quite possibly, is more important than fine-tuning the food choices that you consume during that recovery window. That's something that athletes and coaches don't really consider. I mean, we warmed the skeletal muscle, we cooled the skeletal muscle, we changed the environment, and we find less variation from product to product or nutritional modality than the variation that we see associated with environmental stress during that recovery window.

Danny Lennon: Yeah, that's such a huge thing, and I think it's probably so rare to kind of come across that thought, especially in just conventional thinking around glycogen resynthesis. Is there anything to point to what mechanism is going on there that we have these differential rates between, for example, the one with the temperature, why that was the case?

Brent Ruby: It's probably a blood flow issue when you're recovering in…that's a guess, but when you recover in a hot environment you're really not that used to being in a hot environment, you probably are diverting blood flow away from the gut, so delivery of those nutrients to the skeletal muscle may be delayed because you're sending blood flow to the periphery to help maintain evaporative cooling, but that's one possible mechanism. I mean, there are potentially genes that are altered when the temperature of the muscle is affected. And so we're playing, we're starting to go down that path right now, looking at some of the gene responses with a colleague of mine, Dustin Slivka, at the University of Nebraska, Omaha. He's much more gifted than I in describing those gene responses, both myogenic genes and then mitochondrial genes that are affected – we know they're affected by exercise, but are they affected by environment? It sure seems feasible.

So, I mean, we have the opportunity as humans to interact with a whole host of different environments and the whole concept of periodized training, meaning changing your volume, changing your intensity, all that stuff, that's been around forever. People have now started talking about periodized nutrition, which I remember chatting about ages ago and that's becoming trendy, and then there may be advantages to periodizing the environmental stress that we put ourselves in to leverage some of these adaptations or potential adaptations.

So the environment, it's been discounted for so many years but we live in a world where the environment is vastly different from one part of the country to another and so on, and where the Olympic games are held, they're not always held in one location, so what the athletes are going to face this summer with Brazil and the environmental conditions, that's going to have a huge impact on some of the performances.

Danny Lennon: Mm-hmm. Yeah.

Brent Ruby: So I'm just a big advocate of bringing all the possible factors into the study design rather than just being able to walk away and say, “Aha! I told you, if we add this much protein precisely and this much carbohydrate, maybe

a couple of different types of carbohydrate, look at how much better we are at increasing glycogen recovery." It's like that is an interesting question for a very small room of scientists or people that want to talk specifically about scientific findings and the world of sport nutrition, but you're not going to be able to take those results and hand them off to a wildland firefighter and say, "I've solved all your problems. After your shift, eat this."

Danny Lennon: It's just so fascinating to hear that stuff and I think just thinking about that then, you mentioned the idea of we know about nutrition periodization and we're starting to see research on people recovering, for example, with low glycogen, recovering during that phase has these different adaptations to the muscle and mitochondria, etc., that may affect performance in the longer term. So is it then probably entirely plausible that we could see the same thing with, like you said, periodizing these changes in someone's environment that, depending on the environment someone recovers in, that could have effects on muscle and mitochondrial function, etc., etc., or gene expression, that may have not only a role on glycogen resynthesis but maybe performance down the line? Is that something that's possible?

Brent Ruby: Yeah, I think that's possible. I certainly think that's the holy grail for why a lot of researchers are going down this path, and I think it's going to take a lot of work to tease out the optimal periodized dietary approaches, "train low, race high" in terms of glycogen, all those concepts. I think all those concepts show some impressive data and some really, really amazing scientific findings. However, translating those findings into, "See, I told you. Look at that, I rode a 40K time trial five minutes faster because of this one thing," that is going to be much harder to demonstrate.

So to take something as simple as manipulating somebody's recovery diet or the environment that they recover in or whatever in hopes of changing this, that or the other and some enzymes, genes, whatever, and hoping that that's going to give them a massive boost in performance, I think that's a stretch. The reason I like all those findings is it shows how impressive human physiology is and how just slight changes in one thing or another can affect those mechanisms but it doesn't necessarily downstream alter time trial performance or exercise performance that dramatically.

If you look at the history of people that have won gold medals in a marathon, it's vast on where they come from, what their diets are like, what their training programs are like, whether or not they're using periodized nutrition, whatever. Humans can do awesome things with

almost anything that they put into them as far as nutrient intake. I always love to give people the concept that if Lewis and Clark can do what they did just south of where I'm sitting right now on our campus here in Missoula, when they cross the Bitterroot Mountains and they did so with nobody dying and nobody having a real issue, eating beef tallow candles and horse meat, then do we really need to dial in recovery nutrition that precisely? Probably not. [Laughs]

Danny Lennon: Yeah. I think that's a really important point of just highlighting how adaptable human beings are as a species, and that's why we see these changes, right? Just a brilliant ability to adapt to so many different environmental factors on nutrition. Sticking with glycogen resynthesis just briefly because I think this is a really fun and interesting one to point out, when we talk about the recovery nutrition piece and particular when it comes down to traditional exercise science, looking at endurance sport in particular, there's of course…any time we see a benefit for certain things, so obviously carbohydrate will restore glycogen, glycogen helps performance, etc., etc., we know that the supplement industry will inevitably latch on to these different ideas and create products trying to promote something that's going to be beneficial. So we have all these forms of recovery drinks, meal replacements. We have various different forms of carbohydrate like you mentioned and with each someone else will tell you it's the best thing for recovery and performance. So the study that you guys carried out comparing the sport supplements to I think it was a McDonald's meal or a number of meals that were matched for calories and macronutrients and looked at glycogen recovery and performance, that was just really interesting to me and I think it speaks a lot to the point you made in your previous answer. Could you maybe just briefly let people know what that kind of study setup was and what you found?

Brent Ruby: Yeah, you bet. That was a grad student, Michael Cramer. I presented him with the idea of this study. I really had wanted to do it for a while and I thought it was in my wheelhouse to sort of try and do something like that because it was, I mean, no doubt a little on the controversial side, and so I really liked that aspect of it. He did a fantastic job as one of my master students coordinating that and we all worked together on getting those samples and doing that study.

So what we simply did was match macronutrients. It's not really that surprising to somebody that's familiar with the field if you match macronutrients that you should probably get comparable recovery, especially when the feeding was on the same schedule. So another

crossover repeated measures design, we saw no difference in the rate of muscle glycogen recovery from the two feeding windows. So they do a 90-minute exhaustive interval training session, which is super-effective at depleting muscle glycogen. We've used that protocol in over 150 subjects in all these studies over the years and it works very well, so we have the same exercise protocol. We feed them right after the exercise, right after we get the muscle sample; two hours later, we feed them again. The nice thing about the McDonald's menu option and the timing of the study each day, they show up fast, and so the first feeding window happens when the McDonald's breakfast menu is available, and then the second feeding window happens when the lunch menu becomes available.

And it's important to note that, and I've gotten my share of—it's amazing how mean people can try to be on Facebook and other sites in criticizing your science when they don't even know you and they don't even know your motives or the rationale behind the study or haven't even read the paper. So I got my share of lashings from all sorts of individuals, surprisingly, a lot of them locally from the Missoula area, because of course there's a big thought process behind, "Oh, we need to eat organic and we need to do this and we need to do that." It's like the muscle doesn't care about that stuff, really. [Chuckles]

Danny Lennon: Right. You're getting paid off by Big Mac.

Brent Ruby: No.

Danny Lennon: [Laughs] Yeah.

Brent Ruby: We went and paid for our own food, I mean out of pocket. We went to McDonald's across the campus, across the street from the university, every day twice, four times a day, to get the foods and we just paid cash for them. McDonald's provided no funding whatsoever for this project. They didn't even know it was happening.

Danny Lennon: Right.

Brent Ruby: One writer, one person asked me, "Well, if you say that any food can be used, why didn't you go to like Whole Foods and get foods like that?" And I said, "Well, that's easy. If I would have gone to Whole Foods and gotten fancy bagels and fruit or whatever, we wouldn't even be having this conversation." The point is muscle glycogen recovery doesn't have to be complicated. It's going to happen no matter what you consume. It just demonstrates, again human flexibility and our ability to take almost any

structure of macronutrient as long as it's got some sugar in it and make it a viable recovery scenario or meal.

Danny Lennon: Mm-hmm.

Brent Ruby: So yeah, the other thing that was very important to us was to tack the time trial onto that, because it's one thing to be able to say, “Look, here's the glycogen recovery. That must mean this, that or the other.” It's like no, we wanted to partner the glycogen recovery with the time trial performance. And so there was no difference in the time trial performance either, and it's really important that we're not making this stuff up. This is the result of all these recovery studies. We have a total sample size of 153 subjects over the years with these different environmental studies and everything else. There's almost no difference in the muscle glycogen recovery rate. The times that we have the most dramatic effect on that rate is when we jack with the environment. So the environmental stress is far more able to affect your results than is dialing or calibrating or using a digital scale to quantify what macronutrients you need to take in. That is the result of 612 muscle samples.

Danny Lennon: Huge.

Brent Ruby: So it's a massive amount of data to come up with those numbers and to come up with the conclusion that the recovery is affected by the environment. I mean, I think the reason why people get so interested in talking about recovery, and I've seen this certainly in the world of triathlons when I would race a lot, I felt like, man, these triathletes, they like talking about the recovery foods that they're consuming way more than they like eating them.

Danny Lennon: Right.

Brent Ruby: It just gives them something to share with somebody that probably really doesn’t care all that much. [Chuckles]

Danny Lennon: Hundred percent.

Brent Ruby: Yeah.

Danny Lennon: I mean, we see all the time how people will dabble in the minutiae of stuff looking at supplementation and looking at this new supplement they got to help with their performance in the gym or in a certain sport or whatever their goal is, and yet at the same time they’ll be sleeping for like four hours a night and not paying attention to that. It's like you're missing the

kind of big fundamental stuff we know has a big impact as opposed to going for this stuff that's kind of more of an attractive piece.

Brent Ruby: Yeah.

Danny Lennon: I think it's really interesting to see.

Brent Ruby: Yeah, talking about your sleep patterns and your exercise patterns is not nearly as sexy as talking about your recovery nutrition or your food choices that is new and cutting edge.

Danny Lennon: Yeah, and I think it's a really important point around having a basic understanding of some physiology or some substrate metabolism can be really useful for people because then a lot of this kind of stuff goes a way of, like you mentioned, it's not really that surprising when you have two meals and they're matched for calories and macronutrients that they have the same effect, but yet if you don't have that basic physiology understanding, you can't screen that information and then you start hearing about how organic food or clean food is going to be way better or how these specific supplements are going to have all this amazing effect that you can probably just get from some standard meal.

Brent Ruby: Yeah.

Danny Lennon: So I think that's an interesting piece to it. Brent, we're coming close to time so, if you're good for one more, I really wanted to get to one kind of final question.

Brent Ruby: Yeah, you bet. No problem.

Danny Lennon: Particularly, it centers around more of the hydration especially in the heat because you've obviously worked with a lot of people on that, and one of the interesting things looking at was why someone's performance tanks when they're in a very hot environment and typically this idea of maybe conventionally we would think it's purely down to core body temperature in that they get too hot and then their performance goes down, but I know you've looked at some stuff around skin temperature. Can you maybe just highlight some of that stuff to people what they should know about those and how they affect performance and its decrease?

Brent Ruby: Yeah, that's an interesting area. [Chuckles] I don't know why but I seem to be painting myself into a corner over and over and over with these different challenging thoughts. Most of the time when coaches or athletes or the parents of athletes think about heat stress and trying to combat heat

stress, the very first thing they think about is not temperature of the body, the ability to evaporate sweat. They think about hydration. “As long as I drink enough, I will be safe.” And so they take all the precaution they can to provide excessive access to water, “team mothers” come in and provide coolers with water and they always got to have access to water. Heaven forbid you put on a 5K and not put three water stops in the damn thing because people are obsessed with “I must stay hydrated.” At the same time, there's really no good measure except for nude body weight measures taken in succession to demonstrate hydration status.

So what we've done with some of our studies is we've kind of challenged that a little bit. We've shown people that have had heat injuries accidentally and how much water they consume and show a disconnect between hydration and heat stress. You're more likely to go down on a football field not because you didn't drink enough but because your core temperature and your ability to offload heat is so severely impaired because your aerobic fitness level is so pathetically low. But we've got a couple of papers that are going to be coming out that challenges the volume of fluid that you might need to drink to maintain thermal regulation as opposed to the temperature of the fluid that you drink. And so the primary metric that a lot of individuals have relied on is a measure of core body temperature, which is certainly in the lab. It's not one of the favorites because we use good old-fashioned rectal thermometers for long periods of time and that's not a popular measurement tool.

Danny Lennon: [Laughs]

Brent Ruby: But what we find is that measure is very slow-moving and humans want to stay between 37.5 and 39. As soon as you get over 39C for rectal, it's not very comfortable. I mean, we can certainly see people as high as 40. That's not necessarily problematic. But the range of core temperature is very narrow, whereas the range of skin temperature can be enormous. And when the skin temperature is low because you've got air flow across it and you've got effective evaporative cooling, if you can create a big gap between your skin and your core, that provides an enormous amount of protection. You can already think of uniforms, pads, gear, all the things that are put in place, barriers to offloading heat. Those are certainly going to lead to increased heat stress.

But monitoring and looking at the skin temperature is a fascinating concept that we've been putting a lot of stock into lately. We have a monitor system that we've been developing mostly to help us collect data

and not lose it during some of our field studies because some of the core temperature sensors are not the greatest. These are the ones that you don't have to use as a rectal and [instead] you swallow them. Those don't work all the time and the data is really not that compelling. It certainly doesn't tell you much. Whereas the skin temperature responses are very, very sensitive and we know within minutes if an individual's going to have problems downstream, whereas if you wait to rely on core temperature to decide what to do, it's too late.

Danny Lennon: So with that then, if you have a monitor on skin temperature, you can essentially with that immediate feedback ahead of time be able to pull someone before they're going to run into trouble or at least know that something is coming?

Brent Ruby: Yes.

Danny Lennon: Awesome.

Brent Ruby: Yeah.

Danny Lennon: And is there anything like that that you're aware of that is commercially available or being used within elite sport or is it at the moment still within research labs?

Brent Ruby: Not that I know of. Not that I know of. A lot of the physiological monitoring systems out there, and there are lots of them, I mean, that's been a flailing commercial market for years—the military has certainly put a lot of investment in that over the years—but most often the physiological monitors that are out there are trying to measure too many things, and in doing so, if one of those metrics fails, then the whole thing becomes cumbersome. They're also very difficult to wear, they're not comfortable, you can't wear them for long periods of time, and the amount of data that they provide is almost impossible for the average coach or athlete to make sense of. It's kind of like a jet ski. They're fun for about 30 minutes and after that, now what do I do with it? [Laughs]

Danny Lennon: [Chuckles] Right. Yeah.

Brent Ruby: We're hoping that our system, our sensor suite system, we're trying to look for partners to play with because we know we can have an impact on occupational heat stress. We know we can have an impact on potential training adaptations using that instead of just heart rate by itself. Using that, you instantly know if I go from Missoula to Florida and I want to

train at a certain environmental stress, I use that data as opposed to a flat-out GPS monitor because then I know I'm not going to overextend myself in an environment that may take me two steps backwards in terms of my potential for adaptation. It can also be used to help document very nicely for coaches acclimatization schedules, things like that.

So there's a lot of cool potential with it. It's just we're not really the best hardware people. We're not sitting around with soldering irons and electronics building these things. We've built our systems just based on using commercial products and then getting a good programmer that can build an after-market app so that we don't lose data, we can collect it.

Danny Lennon: Yeah, and I mean, considering the kind of technology boom we're in at the moment, hopefully some of that stuff…I'm sure it's extremely doable and probably hopefully isn't too far away from people being able to use that in the field, so that's really interesting to see you guys using that in the lab. Brent, we're just close to time here so before we get to the very final quick question, maybe you can let people know where they can find more about your work online or if there's anywhere in particular you'd like them to go and check out.

Brent Ruby: That's a good question. I think the easiest avenue for us is our Facebook page is the simplest thing. I can update that a lot easier than any website that we can maintain.

Danny Lennon: So Brent, this has been a really great conversation. I've really, really enjoyed this, and I know especially with a lot of your things that you're doing and kind of questioning things and pushing some kind of conventional thoughts that sometime get well-established without actually the necessary things to back them up, which I think is the essence of good science, so I applaud you on all you're doing. And I'll just finish with the final question we always end the show on, which can be to do with anything, even outside of today's topic, and it's simply, if you could advise people to do one thing each day that would have some beneficial impact on some area of their life, what would that one thing be?

Brent Ruby: Diversify. As a recovering iron man, I am constantly looking for ways to diversify. I think that all the research that we've done shows how flexible humans can be in all these different environments. Why do we always need to train the same way just to get better at one thing? No, I want to get better in a lot of things. I want to get better at working with wood. I freaking love carpentry. I want to get better at that, and so I do more of it.

And that spins off into me wanting to build a better paddleboard. I build hollow-wood standup paddleboards as well, and just the idea of I think the reason why the science is so attractive to me is that my other part of my brain has to work that same way. So I'm constantly looking for new and innovative things to play with, work with, tinker around with, not just the science but if you diversify your hobbies, your interaction with the planet and the environment and the cool places that we get to travel to and live, diversify your physical activity patterns so that you're not just in a gym all the time, you're not just in a pool all the time. You're discovering new and awesome things that could spin you down a different path, so.

Danny Lennon: Wonderful. First time I got the answer and I absolutely love it, so thanks.

Brent Ruby: [Laughs]

Danny Lennon: Absolutely brilliant. I really, really do like that. And like I say, I have so much respect for what you're doing and I really, really love your approach and your critical thinking that you're bringing to this and the work you're putting out. So thank you so much for your time, Brent. It's been absolutely amazing to chat to you.

Brent Ruby: Absolutely. That compliment means the world to me, so thank you.

Danny Lennon: There we go. That's our show for today. What a fascinating area of research as well as just a fascinating guy in Brent Ruby.

In the show notes, I'm going to link up to those papers that we've mentioned today that you can go and read those in full. So that'll be over at SigmaNutrition.com/episode124, and you can also find a link to sign up to the transcripts and I'll also embed the YouTube videos and all the other resources that Brent mentioned over there.

There's also an official support page over on Patreon where you can support this podcast for like $1. Thank you to everyone who has so far contributed and to everyone who continues to support the show. It really does make a big difference and is so appreciated. For any of you that do want more information and want to check that out, if you go to Patreon.com/sigmanutrition, you can find details. And if you do end up supporting the show, thank you in advance. It is very, very much appreciated.

Other than that, I'm honored and thankful for all the reviews that are getting posted to iTunes and the other podcast apps. They also make a

tremendous difference to the show and allow it to continue to grow and build this kind of community of loyal listeners who are regularly tuning in. So thank you for everyone who's doing that. I really do owe you one and I do make sure to read every single one, so thank you for those of you who are doing that.

And that brings this week's episode to a close. Over the next few weeks, we have some awesome ladies on the show including Cassandra Forsythe and Melissa Davis, so make sure you're subscribed to the show so you don't miss out on those particular episodes. And that's it. I will talk to you next week.

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Thank you for listening!