DANNY LENNON: And here we are. Louise, thank you so much for joining me on the podcast there. I really appreciate you taking the time out to do this.

LOUISE BURKE: It's a pleasure.

DANNY LENNON: It's an absolute pleasure for me and quite an honor to be able to talk to you directly after given how many years I've been reading some of your work, which is been some of the most important within the field of sports nutrition. And I'm sure many people listening, be very familiar with your work. So, no need in a way of too deep of an introduction. But just to let people know a small bit about your background, where are you currently based? What is the focus of your work and anything that might be relevant to today's discussion?

LOUISE BURKE: Yes. So, I'm in my 29th year at the Australian Institute of Sport in Canberra. And I've also got an appointment at Australian Catholic university as part of the Mary Mackillop Institute for Health Research. So, the AIS was restructured last year and so the Department of sports nutrition that I had been in charge for 27 years was deleted into sports science. And so the AIS has completely changed its range of activities. No longer do we have sports programs and multidisciplinary teams working with them. But I've remained on in a role that's titled Chief of Nutrition Strategy. And I'm trying to reinvent myself doing

work around our supplement framework, which I think we really want to keep going. I'm doing lots of research projects that are funded by the Australian Catholic University. And I'm just looking for other projects around trying to develop best practice protocols for other dietitians and nutritionists who are still working with athletes.

DANNY LENNON: One of the things that I wanted to get into and probably a good place to jump in as any has been this large project, Project Supernova that you've been in charge of over past several years, which has had several different components which we'll probably get into. And some of that has been, some of the studies have been published from that, some have been just finalized as far as I'm aware et cetera. So just before we get into the specifics of the different parts to that and looking at the most recent and maybe some of the previous papers, just as an overview level for people who haven't come across that before what's the best way to summarize what a project Supernova essentially id?

LOUISE BURKE: Well, Project Supernova is the most credible bubble very enthusiastic coaches, athletes, sports scientists. And it followed a model that one of my old coaches at the AIS, Brent Vallance who works with racewalkers developed more than a decade ago. He came up with this concept of holding training camps in January of each year before the major championships for athletics that are Australia and international athletes would come and train without teams. And embedded in that little project was some sort of research question to answer. And it was a fantastic environment because you'd get really good training and camaraderie amongst the athletes and often coaches would come and be part of it too. But you could do your real life research with the rigor that we like to do with at the AIS and sort of everybody was a winner. And so, Brent is not working at the AIS anymore, but he left that legacy of the culture of doing it.

And so, when I was lucky to get some research funding from Australian Catholic University, I thought the best way of trying to use it was to resurrect the idea of those research camps. And I

work with racewalkers. One of the racewalkers I work with is Jared Tallent who won the gold medal in the London 50k event. And what I've found was that some, he's a really well respected athletes, but the whole, uh, group of racewalkers internationally is such a wonderful group in terms of just the camaraderie and the collaboration and they're more than happy to come and get together and train really hard together and to allow you to intervene, you know, quite rigorously with the training and the nutrition that they have because they feel that they're also researchers. They're just as vested in finding out better ways of being able to train to improve their performance.

: And so we just started small, but we've sort of built up over the last four years into this really cool culture that we have these camps over four to eight weeks at the beginning of each year. We've held some others at other times of the year as well, but we get world class athletes to come in and we completely take over their training and nutrition in the sense that we supervise and feed them everything, monitor every training session, but it's done in collaboration with them. So, we think up what kind of research projects are of interest to them, what they feel could make a difference to their performance and we come up with protocols that are an integration of what's possible with elite athletes. You can't take too many blood samples or take too much any muscle out of their important legs. But they will do incredibly generous and committed activities to work with us to really address some of those clearly questions in sports, nutrition and we all go in with an open mind.

That's one of the things that sort of really frustrates me about the social media commentary around so much science these days. You know, if your data doesn't agree with somebody else's opinion, then you're labeled as being biased or you're doing it deliberately or whatever. And yet I'd have to say, "Look, we're in there to improve performance. What possible reason would I have for not using any kind of a strategy that's safe, effective and legal to improve performance?" If there was evidence around it, I don't care if performance is improved by beetroot juice or ketones, if there's evidence behind it, yeah that's what

you want your athletes to be able to have access to. So, we let the research go in the direction that the research wants and whatever the outcomes are, we write them. We're not trying to push messages or have a very biased view that only one way is the way of doing it.

DANNY LENNON: I think one of the really fascinating and important aspects to this whole model that you've been able to employ here is that it has this wonderful intersection of two important things. One is looking at actual true elite athletes. And then the second is the ability to implement an intervention and have quite a tight control over that. And the reason why this is so important is because those two things often happen in a kind of mutually exclusive way unfortunately in a lot of sports nutrition. It's either you get to pick one or the other a lot of the times. If you look at some of the data and on the athletes, often times it tends to be a bit more case studies or observational and people can't really implement these direct interventions like you say or be able to tightly control everything because the athletes are dotted all around the world. Or on the other side, you can tightly control everything, but maybe you end up working with people who are recreational trainees and some of that may not apply. So, I think this wonderful model you have here has the intersection of both, which is probably why it's been able to generate such important findings for the field.

LOUISE BURKE And look I feel just so lucky to be able to, to work with those two factors, as you said, combining and it's attributed to the athletes. But it's also attributed to the AIS that we've been very careful over the years in developing protocols for measuring things. A lot of the equipment that we have is bespoke where we really control both the input and the output and the quality assurance programs around what we do have been set up by terrific physiologists in the past to whom I must give a lot of credits so that we calibrate things very well. And everything, I mean, a lot of the things we do are from first principles so that people truly understand what's going on. And that's, you know, one of the reasons I think that when we did the first of the keto diet studies, you know, we noticed that the oxygen cost of exercise had changed. And I have to say

that it sounds terrible now, but I wasn't expecting it. I mean, I wasn't looking for it. We didn't go out with the hypothesis that this was going to happen. When you think through it, of course it's absolutely obvious if you understand our clinal pathways around fat and carbohydrate oxidation. But the data coming out Douglas bags analyzers. And I was reading the spreadsheet and looking at, you know, these numbers are moving, they're different. And you know, it was just a really obvious compelling story when you went back later, you thought, "Of course, why didn't we think of this before?

And so now everybody talks about it as if, "Oh yes, we all knew that." But you know, it was only just because we handle the data in that way and have such confidence that we're measuring it precisely that it was noticeable and then helped us to understand a bit more about what this diet was doing.

DANNY LENNON: Sure. And I think we can hopefully dive into that specific study in a bit in and look at some of the work that was published that you just referenced there. But just to clarify, as far as I'm aware, has it been Supernova Four that has just been completed as far as data collection is concerned?

LOUISE BURKE: Yeah so, we've just finished Supernova Four that's with the racewalkers. But we've also started another series of projects (called project SPUDATHON) and this is with marathon runners. And I guess one of the things that I'm thinking about how I'm reinventing myself with AIS is that maybe my new career pathway will be trying to drive lots of research type projects like this with a whole range of sports, not limiting myself just to endurance or racewalkers, but looking for opportunities in lots of different areas of sporting performance to address either performance or health issues. And you know we may have all sorts of cool projects and hopefully we'll be able to build the same culture and a range of other sports where athletes really feel they're getting that even space and truly being part of the process.

So yeah, sometimes you do research and athletes will come in and they're sort of there and they participate in and they'll dial in their performance on the day and

they'll be sort of part of it, but they don't actually feel they own it. And I always like to make athletes feel, look, "You're the guys that are going to win the medals. It's not me. No. You really need to do this project in such a way that when the findings come out, you really trust them and you can think through that experience. You can look at all the data and you are convinced because you were there when it happened."

DANNY LENNON: If you can talk a bit about it, what is the kind of first research question that you're trying to address with this?

So with the Supernova series to start with, as I said, Jared works in the 50k walk area and so it's a three and a half hour event. And so it's sort of longer than an endurance event. It's getting into ultra-endurance and it's really at that crossover of where fuel substrate choices become interesting because there's still capacity. Yeah, it's normally around sort of 70 to 80% there to max is the steady state speed. Although as we'll talk later, it's not just having that speed that's important. The winners of these races are the ones who are able to have another gear when it comes to the 40k mark and they come home much faster. And so it's not just a matter of having substrate for one intensity, you need to have flexibility around that.

But when I was working with Jared for the 2012 Olympics energy, our strategy there was to try to increase his carbohydrate oxidation and his carbohydrate availability. This was at the sort of the beginning of the interest in trying to have more carbohydrate intake during long events. And the race-walking events really cool because it's done on a 2k loop. So you've got access to a feed zone every 2k or nine minutes. So it's a really great event for sports nutrition because you can be - the practicality of feeding somebody is realistic. And so that was the sort of tactic that we used that brought home that gold medal of training his gut and training his behavior to be able to consume very large amounts of carbohydrate. And so that was a success story. And then we started to think, well, what we need to do to go beyond that because you know, you have to keep moving forward and having new ideas to get better.

And I mean I continue to be intrigued by this idea that we've got a lot of body fat stores despite being lean as an athlete and we have finite amounts of carbohydrates. So it's always this sort of mesmerizing idea of why can't we make more use of fat? And prior to this I'd spend about a decade looking at different ways to adapt athletes to high fat diets and periodize it with a fat adaptation period and then restoring carbohydrates so that you went into the race with both energy systems going well. And we just couldn't make it work and there was just, as much as you tried, we just kept hitting a brick wall. And so we'd sort of stopped that in around 2005, but then it's suddenly appeared again, like these ideas just keep recycling. This time the diet that was being promoted was not just low carb, high fat, but it was ketogenic, so very restricted carbohydrate and very high fat intake. And so I thought, well you can't ignore the talk that people as the social media discussions, the papers, the hypotheses. There was no data to drive this new idea or this recycling of an old idea. It was all still hanging on a paper that was published in 1983 by Steve Phinney where cyclists had been glued onto the ketogenic diet for four weeks. But you know, it was remarkable to see it in that paper that the fat oxidation rates of those just doubled, almost tripled. And so you certainly can improve your ability to oxidize fat more than just through training. So I thought, “Well, maybe we missed something before or it’s time to get back and have a look again.” And we also wanted to compare the old sports nutrition guidelines which promoted that the athlete should have high carbohydrate availability for every training session, that they should always be refueling after a session. Always take onboard carbs during the session so that you're always flooding the system with carbs. We wanted to say that was the old way of thinking.

And we've moved now to this model where we periodize carbohydrate around training sessions. So some sessions are done with high carbohydrate availability to drive adaptations around carbohydrate oxidation and gut absorption of carbohydrate. But other sessions are done with low carbohydrate availability to drive the mitochondrial biogenesis and increased fat burning capacity and another range of adaptation. So we thought, well why don't we do a

study that has all three? So the old way, what we think is the new way that has the best of both worlds in terms of adaptation pathways being promoted to different types of training sessions. And then we'll put the ketogenic diet in there. And we recruited some, some of Jared's world class race-walking friends to come.

And we decided that if we're going to do this study properly, we needed to have people really believing in the treatment that they were going to have. There's no point putting somebody who thinks that perhaps the best thing in the world on a high fat diet because you know, they're going to feel like they've been short changed. And when you get them to race, they're not going to try as hard or sort of feel that there's any magic there. So before we screened the athletes that came into the study, we explained the different philosophies behind each of the diets and said, "Which do you think you'd like to go have a controlled adaptation to, you might've heard about this way of doing things before, but you're not sure of how to do it yourself. We can deliver you world class sports dietitians who can make it happen for you and you can have every outcome of your experience of it monitored so that you really know how it worked for you. And we're going to do a 10,000-meter race before and after, an IAAF sanctioned race so that you can really put your performance on the line with these different dietary treatments. And we'll gruel the rest of the sweetness around it; there's prize money at the races. You get to train with great facilities and good friends with you. So what do you think about coming and which of those dots do you want to take your client to?"

And we were lucky that we got almost equal numbers of people picking each of the dots and so we had a really good opportunity to investigate the effect of each of those diets with people who really believed in them under very controlled conditions.

DANNY LENNON: So you've essentially set up a situation where you have these three different types of diet. You have the Ketogenic Diet, you have a high carbohydrate diet, and then you have this periodized carbohydrate diet, which has a altering days of low, moderate and high

intakes of carbohydrate relative to the type of training that's being done, correct?

LOUISE BURKE: That's right and relative to the goals of that training session. So you've got a training session that's a quality session. You're wanting to do intervals or do hill work, well then that needs to be done with good fuel support, said that you can get the best quality outcomes. Whereas if you're just doing a recovery session, it's not so important, then that's something that you can do with low glycogen levels and try and drive mitochondrial biogenesis in that session.

So we set up the training program in collaboration with the athletes and their coaches. So we had six sessions in the week that everybody did together. And then we had the ability to let athletes do some other sessions according to their own programs because we within the group we had some people who were 20k specialists and some who are 50k specialists. So they would have slightly divergent training needs on those sessions.

DANNY LENNON: And so what were the main outcome measures that you are looking to assess?

LOUISE BURKE: Well, we set up a number of different ways of looking at stuff because this is a very expensive study to do, both in terms of the money it costs, but also people's time, and athletes' commitment. So when you do these sort of things, you've got to get in and make sure you get as much information out of it, but try and balance up what you're asking athletes to do in terms of interfering with their training or other aspects of what they need to do versus how much information you can get. So we chose three different things to look at. We had a race before and after and we set it up to be as real life as possible. As I said, it was IAAF sanctioned race with the race judges and prize money. Other competitors could come and be in it apart from people in the study.

: We had a 25 k training session that was done partially in the lab and partially outside. So they'd start on the treadmill and go out and do a lap around the AIS and come back to the treadmill. And it was set up so that we could monitor things throughout the duration of

that two-hour period of training. Because we wanted to see what the longer term effects on substrate metabolism where when you intervene with these diets and it'd be very difficult to get a race walker to do a total two-hour session on the treadmill, it's just apart form that you've got 25 people in your study, you and you haven't got 25 treadmills or 25 lots of scientists who can do it all at the one time. But we could set up a really slick system of having one person on the treadmill and then going out the door and the next one comes on the treadmill.

The other tests that we did was a VO2 Max test which included graded economy tests. So in endurance sporting both running and walking race walking, there's a test that athletes often do, which is to walk at certain speeds, four different speeds, and to look at the economy, how much oxygen it costs you to walk with that speed and as you get fitter and as you get closer to competition, then what you hope is that the cost of walking, the oxygen cost of walking is reduced.

And in fact Brent Vallance, the race-walking coach that I talked about before has been keeping a log of just about every successful racewalker that's ever been produced, who's been through our lab has done this test and Brent has got some magic numbers around. If you're going to be successful as a 50k walker, you need to be able to walk at this speed, this percentage of your VO2 Max because that really shows that you have right economy that allows you to walk at a very fast speed for the three and a half hours with a little bit in reserve to go faster when you need to.

DANNY LENNON: What were some of the main results that come from that? And then from that, how did you interpret into conclusions or implications for practice?

LOUISE BURKE: What we found when we looked at the three groups is that each of the groups improved their VO2 Max over the three and a half weeks of training. And there was no difference between the diets and their ability to improve their fitness. But when we had to look at that economy stage, we found that the fat adapted athletes, those that had been on the ketogenic diet now required more oxygen to walk at the same speed. So even though that improved their fitness, so the same

speed should have been now done at a lower percentage of their VO2 Max. They in fact walked at the same percentage of their VO2 Max because it was now costing more oxygen to burn fat rather than carbohydrates. So, they doubled and in some cases nearly tripled the amount of fat that was being oxidized to produce the speed on the treadmill, but the cost of doing that was it cost more oxygen. And so we found that if we particularly looked at two of the speeds because they relate to both. One relates to the 20k race speed, the typical speeds that people walk at in the other to the 50k. And in both those speeds we found that the oxygen cost increased once you are burning more fat. But with the other two groups who were still burning carbohydrate, the effect of the training period had been to improve their economy. So, they're now walking at a lower percentage of their VO2 Max because it was now higher. And then we got to the race, the first Supernova was done over two different camps because we started small with a group of 10 athletes to disprove that we could be smooth with the way that we did our work. And then we came back and did it again. And so, we ended up having four races and we had to then take into account that there were slightly different weather conditions in the races and what have you. But it turned out that the two groups that had had carbohydrates before the training improved their performance in the races from race one to race two, but the high-fat group, despite the fact they were now fitter and had higher VO2 Max didn't improve. And the difference between the two groups was around about 7% of performance time, which is really a large gap and it was quite pronounced.

And we attributed that to the fact that the race speed which you're doing a 10,000 meters, which is they're faster obviously than you'd going if you're doing a 20k race or a 50k race on average was requiring such high rates or has such high amounts of their VO2 Max that what's becoming limiting in this case is oxygen supply. You know, if you're working at a pace around 80% of the VO2 Max and now it costs you 83 or 84% of your VO2 Max to walk with that same speed because you're needing to use more oxygen to burn fat, well then that's it a detriment to that performance. So, we were criticized with the results because we've chosen a

10,000-meter rise to look at performance. But we felt that it was relevant because you can only ask athletes to race at 100% of their capacity with all their commitment so many times in a year. And we needed to make something relevant to those athletes. So, we knew that they liked to have a shorter hit out just before they do the 20k championships. The 20k championships were a month later than our camp.

And so, we felt that the athletes would truly perform for us two 10,000-meter races because it was in their best interests is preparation for 20k. And if we'd asked them to do a 20k rice or a 50k race at that performance, we wouldn't have got that. They just wouldn't have – yeah they'd be putting a reasonable performance, but they wouldn't have put everything on the line. And we also rationalize the reason for choosing it was because even now I've said that the 20k race on average and the 50k race on average is at a slightly slower speed. To be successful in those races, you have to have some proportion of the race which is done at a higher gear. You know, you have to have the ability to break away or you have to have the ability to sprint to the line as we saw in the Boston marathon. And so, it wasn't a completely irrelevant test to be able to do to apply to other races that might be important for most athletes.

DANNY LENNON: Absolutely. And I think even more so when you take into account the differences that we're seeing. Like they're extremely practically significant right there. That's a big deal when you're seeing those types of changes in elite level athletes.

LOUISE BURKE: Yes and I have to say Supernova two, I'll be pushing the button on the submit part of that study over the weekend because we've got a whole range of papers that we're ready to send out from the next lot of supernovas. We wanted to try and publish them around the same time because we wanted the story to develop with a good frame of evidence around it. You know, sometimes when you put that first paper out there and it's really startling to people because they weren't expecting it, but it's hard to get the full picture. But we thought with the next series of studies, it would be good to be able to tell a story that has a lot more context and ability to look at it from different

perspectives and then put it all out at the same time so that it supports each other.

So we went back with Supernova two and we repeated Supernova One and we put some females in the group. And this time we did it at a single camp. So, there were only two races and we still found exact same six to 7% difference between the groups. But this time the fat adapted group, it had an impairment of their performance compared to their starting race, whereas the high carbohydrate group improved. But the margin between the two groups was still, it was almost identical. So, it's very robust findings. It's very difficult sometimes in research to reproduce your results because we could do it, and with reasonably small sample sizes, I'm very confident that what we've found is very robust.

DANNY LENNON: Yeah, it's certainly extremely comprehensive. And for anyone who was read the paper that came out of Supernova one, they'll know that's just an extremely good example of good quality science and I've got to commend you on that. And people who have been involved in research and see that paper know what a big deal that was. So we've had these two very similar trials. Can you maybe give an overview of Supernova Three and the idea behind what was looked at within that?

LOUISE BURKE Yeah, so with Supernova Three, we went in the opposite direction if you like. I remember when I was telling my very good friend Ron Moore about the results of Supernova One and said, "You know, you're not going to believe this. But being on a high fat diet increases the oxygen cost of exercise." And he looked at me as if I was completely stupid and he said, "Yes well Zans knew that a century ago." And he pulled out for this collection of historical papers these wonderful data sets which empirically we could prove in 1900 and 1,920, people measured the substrate utilization and the oxygen costs of exercise. And they saw these differences between fat and carbohydrate. And Ron said to me, when he was a young physiologist, he did everything from first principles. You know, he collected and printed all their respiratory gases in Douglas bags and he used to hold in, analyze it to calculate the substrate utilization.

And it was a very lengthy process and you could make a lot of mistakes. And he said, the way they used to check that they hadn't made a mistake was they'd check to see the oxygen cost of exercise with the different substrates. And if there was a difference between fat and carbohydrate, then they knew they hadn't messed it up. They probably had to use a slide rule to do all the calculations as well. He said, "Look you people," he said, "You just have it too easy." You just don't understand basic physiology. And he said, "Correct. Not only is a high fat diet going to increase the oxygen cost of exercise, but if we could push carbohydrate even further," he said, "I've done some modeling and I can see, hey, you could take a minute off the world record for the marathon. You don't have to move carbohydrate too much more. So if you had the same athlete with the same aerobic capacity and you have the same anaerobic threshold or whatever you want to call it, ability to sustain high intensity speed relative to their VO2 Max. If you could improve their substrate utilization towards carbohydrate for that same oxygen costs you get more OTP and more speed.

He showed me the modeling and I thought, "Gosh, well that's something we've got to have a look at. What can we do to increase carbohydrate utilization, but at the same time you have to have more carbohydrates to be able to burn because the stores are finite. And if you run out of them, well then that's the end of your race if you've put all your money on the carbohydrate story. So, we've been working on the whole range of different tactics that we can used to try and improve carbohydrate stores, carbohydrate absorption, carbohydrate utilization by the muscle. And so we're still working through that. That's the SPUDATHON study at the moment where we've got marathon runners looking at the performance translation of those changes in substrate utilization.

And so hopefully within the next couple of months I'll have a result there. It'll be much harder to pick up because with the fat transition, we had a very big change. We had people going from being able to burn a half to six grams of fat for a minute of exercise and being able to double and even triple that. And that

creates major shifts in oxygen costs where we're talking about taking carbohydrate, a much smaller percentage increase. So, it'll be very subtle, but we're hoping that it still translates into performance because when you're working with the latest or you're trying to break that two-hour barrier, just small margins are going to make the story much more much fun too to be part of.

DANNY LENNON: Sure. That makes it a ton of sense because it's taking athletes who are presumably already eating quite a significant most of carbohydrate, but saying, okay, if we can get them to be able to oxidize even more than we can potentially see some performance improvements. But we know there's some certain places where there seems to be some types of limits in normal circumstances, whether that's a glycogen storage or the amount of carbohydrate they can ingest at one time without gastrointestinal distress or whatever the case may be. And so, it seems that you're looking at it from the perspective of how can we get them to be able to take on board and effectively oxidize more without these negatives that prevent that from happening. Is that right?

LOUISE BURKE: Yeah, absolutely. So, it's high risk, high reward, I guess. But you know, but it's all parts of the continuum of the fuel story.

DANNY LENNON: So if we just round up before we finish, uh, Louise by talking just briefly about Supernova Four and of course like we mentioned, that has just been wrapped up very recently. So of course, we can't talk about any data or anything, but just from an overview of again, what you were looking at. I believe this one was more skewed towards looking at low energy availability and also then how low or high carbohydrate availability along with energy availability can play a role. Can you maybe again give an overview of what you were looking at?

LOUISE BURKE: Yeah, you've, you've done your homework. you know more than my family does. So, one of the other things that have been very interesting or important in sports nutrition in the last couple of years has been understanding that the energy availability or the amount of energy that your body has available to it, is

always a struggle between the amount that an athlete's committing to exercise and the amount that it needs to have all its body processes running at optimal function? And so, this idea of energy availability, which basically says this is the amount of energy you've consumed, you've committed so much of it to training or to racing because that's got an energy cost and you've spent it there so it can't be spent again. So, what's leftover and then needs to be spread across all the things that your body needs to do to stay alive and to function well.

And if for some reason you eat less or you exercise more, so you create more of a gap between what your body needs to run well and what's left over from training or racing, then your body's going to have to cut back on things. And so that's the underpinning story behind the female athlete triad or the more expansive term for it now, red; the relative energy deficiency in sport. And you know, we say it often in athletics. Sometimes it's associated with disordered eating, but in many cases it's just complete lack of awareness. Athletes don't recognize the energy cost of the training that they're doing or they need to lose weight and so they have an energy deficit for that purpose. And so, it's not a sinister reason that leads to it, but the effect is still the same. Your body has to cut back on some of the processes.

So it's been well described in females, but there's some sort of controversy as to whether it's as big a problem in males, whether there is fragile, if you like, or whether their body system shut down so easily as females when energy seems to be in short supply. And we had as part of our Supernova series, we've always done a bit of a health screen on our athletes when they come in. And we had seen cases of it or symptoms of low energy availability in athletes from time to time in the Supernova series. Sometimes it was the same athlete coming back or sometimes it was one athlete on one occasion, but not on the next time you saw them. So, we certainly were aware that it occurs, but we're going to get to the bottom of it further.

And so our athletes this time came in and we had a period where all of the athletes were on a high energy availability diet for a week just to harmonize

everybody. And then we spread into three groups where we had some athletes continue the high energy availability diet, some athletes switch to a low energy availability diets, so we reduced the calorie intake while they continued training. And then we had a social group, which we put back on the Keto Diet because I'm really interested to know how much of low energy availability symptoms due to carbohydrate restriction. One of the things we've seen in the Supernova series, which is part of the publications coming out now is that carbohydrate restriction upsets a lot of body systems around immune system team and of the inflammatory response to exercise, iron responses, bone responses. And so, I wondered, you know, some of these symptoms that we saw, these, the Keto diet is not low in energy, it's high energy, but it's low in carbohydrate.

And so when you say some of these symptoms with the ketogenic diet we've wondered whether carbohydrate restriction could explain some of what happens when you're low in energy. I mean if you, if you have low energy availability, you've got inadequate intake of all your macronutrients probably so maybe the carbohydrates stories have been the mechanism behind the changes with low energy availability. So, we've had a week of exposing athletes to that and then we've put them back onto high energy availability to see if we could restore any of the perturbations that we saw.

So that's essentially where we are. We've just come straight from the lab today too. We've been going through all the blood samples and trying to get all the data crunched. So, I'd like to be able to get all our Supernova series out by the end of June so that we've caught up with our story and then looking to think about Supernova five and what we can interrogate there.

DANNY LENNON: Awesome. Yeah, there's so much great stuff in there. And just as you mentioned, one the fact that this is a low energy availability study been done in male athletes I think is really important addition to that. And then also trying to tease apart how much of these uh, negative consequences we see are due to a caloric restriction or low energy availability or just low

carbohydrate availability I think will hopefully answer some really important questions. Final thing on that before I finish. In terms of the measures that you're looking at, is it a metabolic rate? What are some of the measures that you're going to assess to try and answer that question?

LOUISE BURKE: Well, we've looked a number of different things. We keep going back to our 25k walk, our two-hour walk and some of the metabolic responses to that around bone, iron, immune system inflammatory responses. So, we'll look to see whether the low energy availability or the low carbohydrate availability with the Keto Diet continues to create differences there.

We've also done, this is a new thing we added this time and it was very much with the generosity of both researchers and athletes. We looked at me overnight profiling of hormones because a new study that's been done on elite athletes looking at low energy availability where it's been as an intervention, looked at just fasting levels of different hormones and didn't really find a lot of change with the low energy availability diet. And so that was one of the pieces of evidence suggested that well maybe males don't have so much of a reaction to it as females. And yet the really elegant studies that have been done to underpin the whole female athlete triad story done Anne Loucks in the 1990s involved looking not at just the fasting levels of hormones, but the pulsatility of hormones.

So we know that a lot of hormones in our bodies have to have a rhythm of rises and falls over the day and during the night, part of the low energy availability effect is to change the amplitude, change the range in which these hormones fluctuate and the period over which they fluctuate. And so we wanted to have a look at that and the best time to do it was night because so many of those hormones do fluctuate during the night. So, we set up sort of like a little orphanage at the AIS where all the beds were in a row with athletes sleeping in them and they all turned up in their jammies with their teddy bears and went to sleep.

And then the researchers would creep in every 20 minutes and take a little blood sample then with head torches and then creep out. And so we're just going

through the whole business now of analyzing all those samples and then we'll need some help from some collaborators, I'm working with Kathryn Ackerman who's at the Boston children's and Harvard hospitals in Boston. And so, she's a world leading endocrinologist and she's going to help us make the story around what's happening with the profile and the change of various hormones through the night and does that change over the conditions that we intervened with?

DANNY LENNON: Before I let you go, Louise for people who are interested in keeping up to date with what you've got going on, the work that you're publishing, is there anywhere on social media or anywhere else on the Internet that they can keep up to date with that stuff that you can point them towards?

LOUISE BURKE: I'm not a terrific prolific Twitter and I have two and I mean I've popped something out there and let people know something's available. But then I have to disappear from social media for a while because it's just gets a bit frustrating when you get the trolls and nonbelievers and all of that, so I'll do my best to get it out there and then take my frustrations away in private.

DANNY LENNON: Yeah, Generally staying away from Twitter is always a good move. I don't think too many people can complain about that. So the very final question for that, you go simply, if you could advise people to do one thing each day that would have a positive impact on any area of their life, what would that one thing be?

LOUISE BURKE Can I have two because I'll live two.

DANNY LENNON: You can have two of course. Yes.

LOUISE BURKE: Do some exercise and vary that exercise. And then the other thing is eggs and chocolate and give your family a hug because they are also important. That's it.

DANNY LENNON: Great way to finish this off. And with that Louise, thank you number one for coming on and talking through your work today. I really appreciate your time and you talking through some of this work and then

also thank you for the continuing amazing work that you were doing. It's very much appreciated by everyone in the field. So thank you for that.

LOUISE BURKE: Thank you very much for the lovely audience, but also thank you to all the people that I work with, because seriously, you can't pull off these kinds of studies without incredible generosity from so many people. And I get to do the talks like this and get a lot of the credit for it, but really I just get to ride on the cocktails of all these other wonderful people.