DANNY LENNON: Nicky, welcome to the podcast. Thank you so much for taking the time to come on and talk to me.

NICKY KEAY: Well, listen, thanks so much for the invitation, always happy to discuss an important issue.

DANNY LENNON: Before we get into any of those specifics that we're planning to talk about, I'm interested to ask a bit about your own background, both from your academic publication standpoint, but also then in practice and your experience within sport and dance, probably specifically – can you give people an overview of some of your background and kind of what has led you to this point?

NICKY KEAY: Sure. Well, I'm a medical doctor, originally did my training at Cambridge University; and then since then my focus has been, both, as you say, clinically and research wise, directed towards athletes and dancers. Actually, the motivation for me to study medicine in the first place was because I was in sport myself, competitive swimmer, and dancing was a big part of my life. And actually I just realized that in order to achieve your athletic, sporting, dance ambitions, you need to know what's going on in your body; and I could see both for me myself, and actually other people I was seeing around,

it's like actually, maybe we're not quite doing – we haven't quite got it right, have we? And it's like, why is that, what's going on, and also, how can we do this better. And why did I specialize in hormones, which is my area of specialization in terms of medicine, it's because hormones, well, they're fascinating, you know, internal chemical messages, can't see them, can't feel them, and yet, they're absolutely super important to our health and our sports performance, because after all, it's hormones that drive the adaptive changes to exercise. So if you're an endurance athlete, you go for a run, etc., or cycling or whatever it is, swimming, and you want to shift your lactate curve to the right and get fitter. But why does that happen? Why do you actually get fitter? What's causing that? And it's your internal hormones or hormones responding to that stimulus, and then you end up being, hopefully, a fitter person. But equally, there can be lots of – it sounds straightforward, right?

So listen, let's just harness our hormones and you become a better athlete, sounds simple. But, of course, there are lots of pitfalls on the way. And if you don't quite get the right balance of training, nutrition, recovery there naturally, it can, you know, your hormones won't work for you. And then, of course, there are medical conditions per se in hormone terms that I've seen a lot of working in the NHS, so there are so many aspects to endocrinology, the study of hormones, that's why I was attracted to that particularly. And, I suppose, I should mention that as part of my career, I was also involved with a study at St Thomas Hospital international team. We were working at an anti-doping test for growth hormone in athletes, because, as I've just said, hormones are so crucial to sports performance. Unfortunately, the downside of that is that some athletes can be tempted to dope, and 75% of doping offenses are actually hormone. So that's not an advert. Obviously, I'm not advertising going and taking EPO or whatever,

but you can see, it sort of demonstrates the fact that they are crucial.

DANNY LENNON: Yeah, and this may come up at a later point, but I'm just interested to ask a bit about dance specifically, because it's not something that I've had really much exposure to either working with dancers or so on, but I think it's very interesting when you start scratching the surface. And so, whilst some people will be aware of typical sports that end up getting put to the forefront of discussions around energy requirements and so on, can you maybe give people an insight into at elite levels of dance, what those energy requirements might look like, some of the aspects that are unique to dance, what a typical training workload looks like, just to give people kind of some baseline?

NICKY KEAY: Yeah. Well, you make a very good point. And in fact, I'm just revising a paper now, hopefully for publication soon, which exactly emphasizes the point you just made. Actually, I would like to say the early work and the availability was actually in dancers. Warren, back in the 80s, and even myself, I did the study of retired dancers, looking at their bone health, and I also did a study of young dancers going through training, to see what the effects of the different types of training load were. So in some ways, actually, I would like to take some credit. But though it started in dancers, but then its focused more on athletes, like you say, athletes where there's, you know, it's gravitational sports, cycling, running, weight dependent sports, martial arts, aesthetic sports, then it's sort of the focus transfer to the sport arena. The irony is, on the one hand, there are so many parallels between dance and sport: dedication, training hours, requirements, all those things, absolutely the same, and psychological aspects of competing or performing.

So going back to what is similar, your original question, it is, number one, often it's early specialization, you know, lots of sports, you get

into that early. And same for dance, because you have to learn the technique of dance, same as with other sports. And in terms of the focus, the dedication, the hours of training, if you go to full time vocational dance training or even as an amateur that I was myself, you are dedicating just the hours of training are very similar to if you were dedicating yourself to a certain sport. So that's it. So obviously that fundamentally is the same. And in terms of the energy requirement, energy intake, dance obviously is aesthetic. When you see the 32 dancers in La Bayadère when they come doing down doing an arabesque on stage, it would look weird if they didn't all look the same. So there is a genuine reason, they have to all look the same, because they're meant to be. The warrior is having a dream, and he's meant to be seeing, you know, visualizing lots of the same person. You see what I mean? So it's meant to be that, the story is that they're meant to be the same in that context. So there's actually a genuine performance reason for dancers being similar.

And also, I have to be honest, having done lots of dancing myself, and as a female dancer, if you do pointe work, when you go on your foot, I mean, I have to be honest, you have to be lightweight, otherwise, it's very – you're just going to injure yourself. You need the strength, and also you have to be lightweight, because you have to do the pointe work. And also, [inaudible 00:09:00] the chap lifts you up, so there's very valid reasons. There's a reason behind it, and it's tricky to achieve the balance, but sometimes that balance can go wrong, sometimes the dancer or the athlete can take that too extreme and think that that's the only way they will improve their performance by getting lighter and lighter and lighter and lighter. But actually, of course, it comes to a point where – of no return, well, not of no return, but it comes to the tipping point where actually now you haven't got enough energy to drive those adaptive changes from the hormones because the hormones shut down.

DANNY LENNON: Yeah, and I think we may actually get into this when we discuss maybe energy availability in more detail later. But I think this is why I think dance is a particularly good lens to view this concept through, even for people interested in it from a different sporting perspective, because as you've outlined, there's these components of not only do we have people who work in credibly hard, who have incredibly long periods of time where they're training or practicing, but you also have this component where because of those body image considerations that may be predisposes people to more of those pitfalls to undereating, let's say.

NICKY KEAY: It's fascinating, that's part of the discussion of my study that we just did. We can look at the sort of external factors, training load, the pressure of looking a certain way, being a certain way, whatever it is, body image, etc. So there's all of that. But actually, what about the internal drivers, what's the etiology of this? I mean, part of it definitely is external. You've chosen to be a ballet dancer, you've chosen to be a road cyclist, or whatever it is, and that sort of comes with it; but actually, you as a person, you go – why do you become a successful athlete or dancer? Because you are driven, determined, obsessive, all those words, you want to be in control. And so, I think that's maybe what you were touching on there that actually there is internal etiological factors, and that is exactly why on the IOC, International Olympic Committee, consensus statement about RED-S which kind of building up to relative entity deficiency in sport, although I do take a slight issue with sport, but anyway, we'll keep that for a different day. I mean, it will be too long if we said sport and dance, it would just become too long. But whenever I'm saying sport, read it as a high performing, you know, well, dances and athletes, all right.

So anyway, in that diagram, there's a reversible error between psychological factors as being a

driver and a result, a cause and a consequence, because, like I said, if you're already of that determined sort, you can see it could very easily spill over in between to taking it too extreme, too far. But equally, once you're in that situation that your hormones have shot down, it has effects on cognitive function and making good decisions and your mood and everything. So now, once you're in that situation, it's actually very difficult to rationalize and accept is what I find. And say, well, actually, yes, there is a problem. I do need to calm down the intensity of my training, and I do need to eat carbohydrates again or whatever it is. So that's very interesting, the psychological aspects are fascinating. And the more and more I delve into this, the more and more I find that actually it's all about athlete behaviors, and persuading them, that's become a job, persuading them that actually there is a – they do need to change their behaviors, but I come at it from a factual point of view because athletes and also dancers, they want the facts, it's like, if I show them their blood tests, and I say, look, this is what they look like, this is what they should look like, it's like, okay, now you can see there's a problem. If I can give them those facts, then that helps them overcome maybe those psychological barriers to changing their behaviors.

DANNY LENNON: And I completely get where you're coming from with some of those psychological components that, in many ways, it's a double edged sword because they can contribute to positive performance. And I've seen, I've worked with quite a lot of mixed martial artists and boxers particularly, and they fall into a very similar thing you describe of, not only do they have this risk factor of competing in a weight class baseball, but all those things about mental toughness and so on that are cultural to those types of sports can end up backfiring then in a situation where they can just grind themselves down with really restrictive eating despite high training workloads.

NICKY KEAY: Yeah, and also almost liking to make yourself suffer, if I can put it like that. The commentators on the cycling, they always say about ability to suffer, and that's what it is. So it's almost like it feels good. I know this sounds a bit weird and masochistic, that you are really, you know, you're feeling it. But as you say, it's distinguishing between where it's positive to suffer, and where actually it's a warning sign of your body, saying, look, honestly, this is too much, and I can't, I'm just going to have to downregulate hormones and whatever it is to save the body really, is what it is. But the mixed martial arts, the weight category sports, obviously that's a particular area because it's times when you're competing, I mean, please correct me, because you have to be of a certain weight. And so actually, it's the fluctuation of really restricting maybe and then sort of releasing, as it were, I mean, actually, if we're really – it's difficult, you can't say one is better than the other. You could say, well, maybe if someone is just low continuously, is that better than being okay and then like this, dipping in and out, but listen, I think, however, whichever way you look at it, the hormone is not going to be happy. So that's really the tricky thing, isn't it?

DANNY LENNON: Yeah, and there's definitely things we can circle back to on that. I did want to ask though, because in our email discussion you had mentioned some recent work you've been doing on some female hormone profiling with Scottish ballet – can you maybe touch on some of that and give some overview into some of that for me?

NICKY KEAY: Sure. So one of the sort of the classic warning signs of RED-S, relative energy deficiency in sports for women is lack of menstrual periods, amenorrhea, so when the periods stop for six months or more. That's obviously a clear warning sign that your hormones in the woman has shut down. So why should you watch the value of tracking female cycles, you could say. So at a very basic level, the first thing is, it's a

super easy clinical sign, and also, it's a training metric. I mean, we record heart rate, and I don't know, whatever, all these other things, power, if you're a cyclist. But actually, one of the easy ones for a woman is just being aware of your menstrual cycles. And if they stop, then that's a warning sign. So that's the first reason to do that. But also, if you are having regular menstrual cycles, I mean, hooray, that means you have got the training load and nutrition in good balance. But then looking into finer detail of that, as we know, some women suffer quite badly in terms of there is a fluctuation of hormones in the menstrual cycle. That's the nature of it – carefully choreographed variations in the female hormones, quite dramatic ones actually, if you look at the graphs.

And listen, some women just aren't affected by these, and they just get on with it, and that's great. But others, there are problematic times, especially if you're a dancer or an athlete, you know, menstruation itself can be painful. But you can't choose when you're going to compete or perform one leg. What happens if it's going to coincide with that? What are the strategies? And also, the other classic time when the woman might feel it is just before the menstrual bleeding and what's called the luteal phase. So there's a high level of progesterone and some women do feel more sluggish, difficulty sleeping, the body temperature rises, the metabolic rate rises. So it's harder to keep control of blood sugar levels and things like this.

But by being aware of this, and that's what we're doing – so that's what we're doing at Scottish Ballet at the minute – I was flabbergasted that... Well, not really flabbergasted, I was surprised – I was surprised and not surprised. On the one hand, I was surprised that not many training systems include menstrual cycle as part of the package, like I've said, it's a training metric. And so, that's what we're trying to do at Scottish Ballet,

we're trying to integrate it into everything else they're recording. Dancers record their wellbeing, their training load, all these sorts of things, and so there we're integrating it with their menstrual cycles, what's going on. And then I, as a doctor, kind of, look and I can see, number one, I look who isn't having a menstrual cycle. I need to have a chat with them and see what's going on, you know, what's happening. Or if they're reporting they're in a certain bit of their menstrual cycle and that coincides with they are not – they are just feeling bad, then I can give them – go and see what's happening, and that's where the menstrual profiling comes in. We're doing blood tests, so I can make their own personalized curves of what their hormones are doing, correlate that to how they're feeling. And then again, just giving information, as a woman, why shouldn't we have this information?

And then, because we want to understand our bodies, but if you can see, this is what my hormone is doing, this is why I'm feeling like this. Then it just makes you feel more confident, okay, fine, there is a reason, I'm not going mad, this is valid, you know what's happening. And then I can help give them practical advice. It will be all personalized and tailored according to what they're doing. So we've just started that part – we've just started doing that. Well, we just started doing that. The unfortunate timing of it with these things is that it was just when lockdown was happening. So we were also meant to be checking bone health, but that's on hold. But anyway, we started out with, use the questionnaire which I mentioned, I'm just hopefully getting published now, sort of a health screening questionnaire and also flag up any risk factors for low energy availability. And then they're tracking everything which they were doing already, but in addition to the female cycles, and also were doing the blood tests with everyone, whether you're man or woman, you're having some blood, just see where you are.

And then for the women, particularly who are menstruating, and not on hormonal contraception, so I think maybe we should just mention that. Of course, it's every woman's choice, if they want to take – what form of contraception they want to take. But the only special consideration if you're a dancer or an athlete is that hormonal contraception, it is going to basically, in the case of the pill, the combined oral contraceptive pill, it just switches all the female hormones off. So it's like, we've lost our menstrual tracker there. Progesterone only isn't so heavy duty, but of course, it takes away the sign off and of the menstrual bleed. So we're a little bit in the dark, if I can put it like that. But nevertheless, but if the dancer is taking it for contraceptive reasons, of course, that's my worry. It's just a concern, and I've seen a few, well, many dancers and athletes who have just been bunged on that, because then psychologically, the combined oral contraceptive pill makes everyone feel happier, oh they're getting a bleed, but it's withdrawal bleed, not a real true menstrual period because of their own internal hormones. So anyway, the summary with the Scottish Ballet is this is pretty groundbreaking, not just for a dance company by the way, but I think overall for sports that we're trying to combine everything together and give the best possible advice that we can.

DANNY LENNON: Yeah. And it seems that that would have this double prong benefit of one being informative of, like you say, being able to explain to an athlete why they're feeling a certain way or maybe why their performance feels like it's dipped this week and so on. But then also maybe there's implications for practitioners to be able to make modifications where necessary at certain times across the cycle. Are there other typical points then across the cycle that you think there are some real considerations, whether that's for the nutritionist, the strength conditioning coach, their head coach, to maybe

think about how they program for their athlete?

NICKY KEAY: Yes, so that's part of what we're developing with this whole sort of system, if you will. Well, typically, it's the menstrual bleed, it can't just, frankly, be painful, okay? And cramps and things like this, and if you are losing a lot of blood, obviously, you're losing on. So that's a nutrition thing. But also, it's been shown in studies that if you do some sort of more relaxing things like yoga, Pilates, etc., that can help. Personally, I always used to find if you can get to a swimming pool, mind you it's difficult these days, that can help just sort of literally try and relax the muscles. But the luteal phase, those two weeks before the menstrual bleed, typically can be problematic ones because the metabolic rate is increased, and so it's more difficult to control your blood sugar levels. So certainly that's where the dietician and nutrition can help to make sure that they're taking more regular snacks. I mean, they should be anyway, frankly. But more regular even than normal, after a morning class have a snack and then you do rehearsal, have you lunch, and then whatever.

So just being mindful and not getting to the end of the day and thinking, oh, you know, it's a lot about planning ahead the strength and conditioning. I mean, to a certain extent it also depends how the person feels, but certainly also working with some female footballers, the strength and conditioning coach was telling me that they often report having heavy legs during the luteal phases, and so actually just lightening the load if you're doing strength and conditioning is not such a bad thing during that cycle for some people. So for sure, you make a very important point that it's just not – just me as the medical doctor, I can give them some basic guidelines, like we said, but actually, if they want the nitty gritty of it, then that's when I will hand over to my colleagues in regard to nutrition and certainly strength and conditioning – at Scottish Ballet we have, I

work with my colleague, who's a clinical dietitian and also especially is coming in for the strength and conditioning. So we always have a chat what's, well, virtually nowadays, but anyway. And also dancers who have run into problems, who have developed RED-S, relative energy deficiency in sport and who've developed a stress fracture or we were concerned that they might do, then that absolutely is a team-approach as well.

DANNY LENNON: So there's obviously impacts of different points in the menstrual cycle on injury risk and performance. However, one thing I think you've done a really good job on in some of your publications and lectures that I've seen, has been pointing out that it's not this thing that we should view as always negative, because I think that's quite common within sport, let's sweep this under the rug. As you say, just put someone on the pill, now everything goes away and we can imagine that it's not real. Or many athletes just see it as an inconvenience to get rid of or it's a problem. Or there's even a culture of, well, for elite athletes, we should just expect that they'll lose their menstrual cycle and so on.

NICKY KEAY: You know, it's not a badge of honor that your periods stop. It's a sign actually that, frankly, you got it wrong. And also, even amongst my medical colleagues, you know, oh well, it's normal for a female athlete or dancer not to have periods. Listen, just because it's becoming more common type dude, on the other end of the spectrum, by the way, we have an obesity crisis, we have type 2 diabetes rates. Just because now type 2 diabetes is sadly becoming more common, doesn't suddenly make it normal. So just because something, you notice that a lot of situations of amenorrhea, that doesn't suddenly make amenorrhea normal in anybody. There's a definition from the Royal College of Obstetrics Gynecology of lack of periods. It's a medical condition. So it can never be normal. Sorry. That's absolutely number one fact. But also equally, it's not

normal if your periods stop, and having periods is normal – good, bad or ugly, those hormones, you need those hormones. So all about going back to the hormones. So women, you need those hormones for your bone health, you also need them to help prevent soft tissue injury. We know there's a high risk of both bone stress injuries and soft tissue injuries, if you are amenorrheic. We also know it has an effect on neuromuscular skills. So reaction time, peak power strength, all that sort of thing. And also it's a neurotransmitter as well, you know, cognitive function, mood, all those things. So why wouldn't you want your hormones? You see?

So, okay, fine for a woman, they happen to come with the consequence of a menstrual bleed. But that's a good thing, by the way, it's a sign. And yes, it's true. They are fluctuating. They're one of the most fascinating and interesting and intricate systems of all the hormone networks. But yes, unfortunately, that's normal physiology. For someone, it doesn't affect them at all, they just carry on and there's no particular problem, just remembering when your menstrual bleed isn't being prepared. But other than that, there's no problem. But it's true for some other women, there can be some problematic times, like we've discussed. But listen, that's life, isn't it? Everyone's individual. Everyone's individual. People have other things that they have to – some people have, I don't know, other things, give me an example, I'm trying to think of something. Some people can't do a handstand. Some people can't, I don't know, find it really difficult to do that. I find it actually very difficult. My legs haven't got the same degree of turnout for ballet, but that's just the way it is, that's just who you are. So you just have to know yourself. I think it's all about accepting who you are, and just working with, and knowing yourself, and that's what I mean about the information, giving athletes as much information as possible.

So I show my athletes their hormone graphs. I explain to them in an understandable way, look, this is what's happening during the cycle, you know, all that sort of thing. And if you realize that actually, yeah, okay, I can see the logic of that, how that is important for my health and my performance as a dancer or an athlete, then it just makes a lot more sense, and you just work with what you have in your body, that's the way you are. So I think that's also part of it.

DANNY LENNON: And so for those athletes that perhaps maybe are on oral contraception in lieu of not being able to track their menstrual cycle as this nice indicator, what are some other things that they could possibly look out for or what type of attention to detail should they place now because they don't have this early warning system?

NICKY KEAY: Well, that's a very good point, and it's a tricky one. But the way I approach it is, well, first of all, I just double check that they're on hormonal contraception for contraception, and they haven't just been bunged on it for whatever. Right? So that's the first thing. But then there's other things you can be aware of, because if they're in low energy availability, menstrual cycles, as I said, is the key warning sign. But there will be other signs that you won't be able to have very good sleep or you're just not performing to your best or you just don't feel good. And from the point of view of getting hard data, I still do blood tests. Okay, the female hormones per se now will be a little bit... won't mean a lot. Right? Either because they've been suppressed by the pill or because we don't know where they are and their cycle is on there, they're on progesterone. But anyway, but there are all the other hormones and all the other markers that I look at very carefully, especially thyroid function, because that gets suppressed; metabolic rate and thyroid function get suppressed, if you're not fueling adequately in your low energy availability. And all the other blood tests that are valid, the full

blood count, what's the hemoglobin, what's the iron, what's B12, what's the vitamin D, what's cortisol stress hormone, there are plenty of other things I look for on a blood test, and also, more importantly, in the clinical history what are they telling me – are they just telling me that they're training crazy hours?

They're not fueling enough, you know, just what do they say to me. Oh they're avoiding carbohydrate, they're not having snacks, they're not getting enough rest days recovery, just from that clinical information or you know what – it's like, okay, fine, that doesn't sound great. And then you can back that up with asking directed questions: how are you feeling, how's your sleep, how's your digestive system, that's often quite an interesting one. I found, particularly in female athletes in low energy availability, part from the period thing, if it's a sign. Also, actually digestive issues is the second in my clinical experience on the list. And then I say to them, how's your digestion, and invariably. Well, first of all, I ask them about the training load and their true nutrition, so pretty much already in my mind, I've got in mind – this sounds like something. So then I ask them the key questions. And the second one on the list, which often comes up is digestive issues, it's like, oh yes, now you mention it, I get really bloated, uncomfortable, constipated, which is a weird one. Because intuitively, if they're eating loads of fruit and vegetables, which they will be doing either way, they'll be eating, sackfuls of lettuce and all these sorts of things – and so you would think, well, surely they're eating all this fiber, why are they constipated. It's because in low energy availability, the gut transit time is slowed down, and like any process in the body, you need energy to digest.

So that's a very interesting one. But often they interpret these digestive issues as being that they need to restrict something or maybe it's because I'm eating too many carrots. Well, I mean, it probably is, but you understand what I

mean. But then they start restricting even more and more and more, and then the problem gets worse and worse and worse, and they interpret that as actually it must be something else I should be restricting. So it ends up as a vicious circle, and actually, that's one of the difficult things to overcome even if you can help them restore their menstrual cycles, assuming they're not on the pill. With downing the intensity of training and looking at the nutrition, even when the menstrual cycles hopefully come back, sometimes there can be some lag with digestive issues. And so to a certain extent, you have to encourage them to push through that and split up – well, by the way, at this point, I'd have probably asked more detailed advice from my clinical dietitian pod colleague because I don't want to step out of my, you know, but I can give them some general things. It's like, listen, you just need to eat mechanically, split it up, and all this sort of thing, and that helps to resolve those digestive issues.

So there are definitely other warning signs that one can pick up on even if they are on the contraception. I mean, it makes it a little bit more tricky, it's true. But then it kind of makes them like a man if you're not, I mean, because, you know, okay, sure, I will ask the medical doctor I can, the male athlete or dancer about number of morning erections, because obviously that gives you an idea of their testosterone equivalent of the estrogen. But otherwise, there aren't so many clear cut things like a menstrual cycle. So I would be asking about sleep, digestive issues, all these things. So there are plenty of other things you could be looking to.

By the way, how are we doing for time, because one of the just little, just to touch on, I was just thinking about the older female athlete, because I've had quite a few age group athletes who are entering perimenopause or going into or are menopausal, and it can actually be quite tricky, because perimenopause, it can be

confusing. Is it a thyroid issue? Is it perimenopause? Is it RED-S? A little bit tricky. But fortunately, of course, hormones come to the rescue. So if you do some blood tests, and you look at the patterns, you're looking for certain patterns, you can see if it is RED-S, or it can even be a combination, I suppose you could argue. But you'll get more information there, and again, that's where the profiling that we're developing will help with the perimenopause to see what's going on with the female hormones if they're out of sync.

But yeah, we should, especially as I am myself, an older woman, should I say, of a certain age, still dancing, we shouldn't forget that if you're – whether you're a professional athlete or dancer or not, you still probably want to continue doing that, whatever it is you've been doing, whether it's dancing or whatever sport it is. And why not? Of course, you should be. So it's not like, oh that's the end, you can't do exercise anymore as you get older, especially for women, of course. Yes, it is challenging time, I can say. But definitely, there are ways, strategies so that you can continue to do what you want.

DANNY LENNON: I'm interested from some of the dancers and athletes that you've worked with, when we think of low energy availability, there's, of course, some acute symptoms that emerge quite early, then with chronic low energy availability, we have increased risk of various issues. You've mentioned bone health, for example, there could be things, cardiovascular disease risk, things like that can be tied into it. In a situation where you correct that low energy availability and bring back up their energy intake, let's say, or decrease expenditure, is there a certain time lag in terms of various other symptoms, how long it takes to correct, so to speak, or that recovery timeline, is there any kind of even anecdotes of athletes you may have worked with or what that recovery might look like?

NICKY KEAY: Sure. Well, I think the first point say is actually would be far better if we could prevent this and spot the risk factors in the first place, rather than waiting for the stress fracture. And for female athletes, there's already the LEAP-Q questionnaire, and hopefully this paper that will be published soon is for dancers. It's looking at extra things and male dancers as well, what are the warning signs. So ideally, in the first place, we should all have some sort of, I suggest, a screening questionnaire too, because you're going to be able to pick out warning signs that really ideally the etiological factors we discussed, because it would be better if you can pick it up in the first place when there are little simmerings that this person is the person at risk, because already they're showing anxiety about what they're eating, what they're weighing, etc., like this, and little warning signs there. Those are sort of the risk indicators for low energy availability. And then if you go into low energy availability, like you say, there's a sort of a sequential shutdown of the hormone systems. And then by the time you present with a stress fracture, you have now got RED-S, you've now got the clinical consequences. And, I mean, that's too late. I've seen – it's very sad, I've seen athletes, some triathletes just recently 19, stress fracture the hip, and that's their career over before it's even started. So that shouldn't have, you know, it's really sad to see the end.

So you're right. There's a sort of a sequence. There's the warning signs, the risk in the beginning, then you start to get – then say it progressed, and you get into, like you say, the acute things, but it'll probably come a bit later, acute things that the hormones are not happy. By the time you get the clinical consequences it's like they're already quite a long way down that path. So that's a bit scary. And by the way, in addition to the bone issues also, the long term consequences is actually adverse body composition. They did a study with gymnasts and they found – this is the irony of the whole thing – the athletes ended up doing this or

dancers because they think, oh I'm going to improve my performance, and if it's a body composition thing, whatever. But actually, they showed that because the body is so stressed, cortisol is high, hormones are down to build muscle, they actually tend to put on more fat than lean mass. Isn't that sad? So that's kind of a bit of a gloomy thing, but the good news is that the earlier you can, first of all, the earlier you can pick it up, the easier it is going to be to help them restore, okay, ideally, at the very, very start, but at least if maybe just their periods are showing a little bit of a wobble or they've just missed one or two, or something like this, picking it up early is really super important, because you're way more likely to be able to reboot the hormones, of course, it makes sense, common Sense, isn't it?

But once they're sort of further down the line, and it's still possible, but it will be a longer journey, and a lot of it is patience, and me telling the athlete, because they think – I've had so many come back and say, oh well, listen, I'm starting to eat carbohydrate again for a week and my periods haven't come back. It's like, well, that's probably because you haven't had any period of two years, it's going to take time. So actually the most important thing, and that's often my job as well, trying to keep them motivated and say, look, you got to stick with this; honestly, you have to go with the process. But then once they start to feel better, the moment they start to feel better, which they will probably even before their periods start, it's like, well, the dancer – I had a dancer recently say, actually, what I noticed first was that in class, I was just more on the ball, I could pick up the steps quickly because in a dance class, you are fired, you are told right [inaudible 00:42:28] you're given the whole instruction list, and you have to process that pretty quickly and do it. And so she said, I could pick up the steps really quickly, and I could implement corrections, because if you're told, oh you're not pointing a foot or whatever it is, that neuromuscular connection you can

quickly do it, correct it. So once they start to feel better, then actually, then that will build.

In terms of reversibility, there is sort of a mixed bag. In my study of retired dancers, you know, unfortunately, I found that actually, their bone density was still below what you would expect for their age, even though they had returned, their menstrual periods would come back if they had in their career delayed onset of menstruation, late menstruation and/or periods of amenorrhea, there was a kind of like modeling that there was an effect on the bone health in the long term. So that's kind of not such a good story. But on the other hand, certainly, from my recent study in male cyclists, if they did take on board my advice about nutrition fueling around training, skeletal loading exercises is good news that actually they did improve their bone density in just a very short period, only six months. But on the other hand, those, by the way, those that didn't, I couldn't persuade or actually was part of the study to be fair. I divided them into two groups, some I gave education advice, and some I didn't, and just let them do their own thing. And the ones that just did their own thing, concerningly by default, went into this mindset of it's race season, if I lose weight I will race faster. Number one, they didn't race faster. They actually didn't win as many BC race points as the other guys. And secondly, they lost bone mineral density to the same extent as an astronaut in space on the International Space Station over six months.

So like, yeah, so there's sort of, like whenever I speak to athletes and dancers, it's like, listen, I can be bad cop and good cop. I'm going to do the negative first. I get the negative out the way. It's like, look, you're going to lose bone density like an astronaut. I just sort of tell them all the negative things, like you said. But then I say the good news is if you do these things and change your behaviors, and I'll be there to support you and encourage you and all this, then actually, not only will you be healthier,

you actually perform better. And I've got now strong evidence from my cycling study that it's true. And certainly, I've got for dancers a little bit different because there isn't like a competition as such, scores, and there isn't, like the power output you get from the cyclist, it's not quite the same. But still, they will, if they come back and say, I'm feeling better, I can perform better, I can pick up the steps, that's basically performance, isn't it?

So I do that, I do the negative and then I do the positive because some people and some athletes say I just want – some athletes want me to be really mean, some athletes say just give me the negative. Right? Others say they don't like that so much, and they say actually they want more the encouragement thing. Either they say that to me directly how they want me to do it or I can kind of judge if they're the sort of person that likes the carrot or the stick or a mixture of both or whatever you see.

DANNY LENNON: Yeah. No, and that's ironic but also the good thing, like you say, that it's not only pointing to, here's the things we can do to benefit your health for even the athletes who claim that they don't really care about their health as long as they're performing; now, it's like, well, look, this is benefiting your performance. Right? This is across the board it's a good thing.

NICKY KEAY: That's definitely a strong argument, and that is a strong argument, and that's the IOC statement. I mean, as you know, there are some critics of RED-S who say that actually where's this evidence for the performance. There is some, like I said, the neuromuscular skills being decreased in amenorrheic athletes; and also in swimmers, female swimmers, they show that they couldn't improve their 400 meter sometime. And now I've got the male cycling study, to my knowledge, that's the first one in males that says, look, actually, there is an effect on your performance for male cyclists. And now I'm developing it, I have more evidence as I go along with the dancers, saying, actually

now, the ones saying yeah that it feels, apart from the anecdotes, I definitely have also with the Scottish Ballet, hopefully, we can also sort of say, look, now we have got some more evidence. But certainly, from a clinical perspective, that's universally what they will come back and say. And now I feel so much better, isn't the main thing, I feel better, and so if you feel better, then of course, you're going to train better, because if you feel that for you, if you're really pushing yourself, you know how it is, sometimes there are all those days anyway. Right? But if it's all the time like that, but you have this degree of exercise dependence where you just push yourself, you feel guilty if you don't do the training session. So having that flexibility, and this is where the coach is really important as well.

I often speak to the coaches and say, look – with the athlete, I say to the athlete, listen, with your permission, can we have a three-way meeting discussion. And I say to the coach, listen, just for the time being, please take out that really high intensity track session, or whatever it is, because everyone's got to be saying the same thing, otherwise there's a problem.

DANNY LENNON: And I think one of the critical things that you said that I want to just reemphasize and go back on is when we look at that time course of with this low energy availability, and as that becomes chronic, it's this progression from these symptoms into actually these long term clinical manifestations with our problem. And I think that the big thing there is for athletes to realize, hey, you need to take these warning signs seriously. It's not this thing of, oh, here's some symptoms, and as soon as you increase your energy backup, they'll reverse. And that leads athletes to fall into this trap of, oh yeah, I'll put that off until the season is over, or I'll put the off until after this event or after this race; whereas you made that clear case that, no, the longer this stays established, you're putting a risk of there might be a point of no

return, at least not to a complete baseline for some of these long term manifestations.

NICKY KEAY: Yeah. No, that's a really, very important point, and I've seen this very many times – oh yeah, sure, I'll do that, I'll do that when I've done the marathon. It's like, ah... And then, yeah, it's like, well, actually, and then they did it, and then they got stressed. So yeah, quite, it's not a case of putting it off. Please don't. And also, I think you also, just to pick up on that point you made there, the other thing athletes say is, oh well, if I just eat a whole load, and I keep doing these crazy training hours, again, sometimes the body – the body doesn't distinguish where the stress is coming from. It could be coming because you're underfueling, it could be coming from the training load. So actually, in those athletes, also persuading them that just for the time being, it's not forever, just for the however long it is, whether it's weeks, months, I can't always set, it depends, can you look at the nutrition and also you have to dial down the intensity of the training because invariably, I also find if the athlete say, well fine, I will just eat more and then I'll just keep doing double sessions at high intensity, it's like, I just have to say to them that it's not going to work. Sometimes I can't persuade them, and then we have to go back and say, fine, let's – they are willing to do that.

So it's a sort of, I'd say, negotiation. You understand what I mean, it's a tailored approach, if you can put your arguments and everything and offer practical solutions, offer just a quick word on faster training. I had an athlete the other day who had decreased the intensity of their training. They weren't running, they were just doing, well, when I say "just", they were doing just sort of like a low resistance spin or some strength conditioning. So low intensity, but they were still doing it early in the morning before work fasted. Right? And with no really proper recovery afterwards fuel. And so that is just like massive, massive stress on the body. So we had to talk about the

fueling overall, I mean, they weren't eating enough carbohydrates or hardly any that I could see. But also, it was the timing of the fueling around training – well, there wasn't any talk. So there were so many aspects to look at, but it will depend on the individual what they're doing at the moment. And, as I say, just coming, just molding it for them, what they're doing now, what we need to do, and warning them that actually we still might have to make even further adjustments or whatever it is.

DANNY LENNON: Before we wrap up, Nicky, for people who are looking to get more of your information, the work you've put out, anything else that they might be interested in, including the webinar you mentioned, where are some good places on the internet that you'd point their attention towards?

NICKY KEAY: Well, my own personal website, Nicky Keay Fitness, and on there I have – I stick all the presentations and webinars and things I'm doing. There's also my publications on there, and some blogs and so everything is there. But otherwise, specifically for RED-S, if you want a free educational source, then I wrote the website called health4performance.co.uk for BASEM, British Association of Sport and Exercise Medicine. So there's information on there, which sort of covers quite a lot of what we said already. Also, I've just written a course for coaches working with young female athletes. That's also available. You can see that on my website. But that's a course for coaches. And we're also making a version of it for the athletes and parents. Okay? It will be the same thing. So important is the same information. So those are the main places you'll find stuff, I think. With regard to the blood tests, I'm the Chief Medical Officer of Forth Edge, that's where we're developing the researching the female hormone profiling for Scottish Ballet, and hopefully running that out. And also, that's where I do all my blood tests for the athletes I've been mentioning, because on the NHS, I mean, I think it's only fair, the NHS is

overloaded at the moment, and you know. So actually for athletes and dancers doing blood tests, I think I can offer it through that, and also I can tailor it to what I need to do, because I know for a fact on the NHS, having worked in the NHS for 30 years, I know that it's very, very difficult, even if you'll get on very well with your lab to get T3 method, for example. So I can get all the tests there, so if you're interested in that side of things, the hormone blood tests, that's the company I use. But again, all the information is on my website. So yeah, I'm really happy people to get in touch with questions and whatever.

DANNY LENNON: Brilliant. And that will all be included in the show notes of this episode for everyone listening, so you can go and check that out. And with that, that brings us to the final question I always end the podcast on. This can be completely outside of anything we've discussed. And forgive me for such a broad, generic question, but it's 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 might that one thing be?

NICKY KEAY: Well, if I can persuade you to indulge me.

DANNY LENNON: Please.

NICKY KEAY: So according to Hippocrates, if we could give every individual the right amount of nourishment and exercise, not too little, and not too much, we would have found the safest way to health.

DANNY LENNON: An excellent way to round out this discussion. So Dr. Nicky Keay, thank you so much for taking the time, but also for the great information and the work that you have done and continue to do, it's very much appreciated, so thank you so much for this.

NICKY KEAY: My pleasure.

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