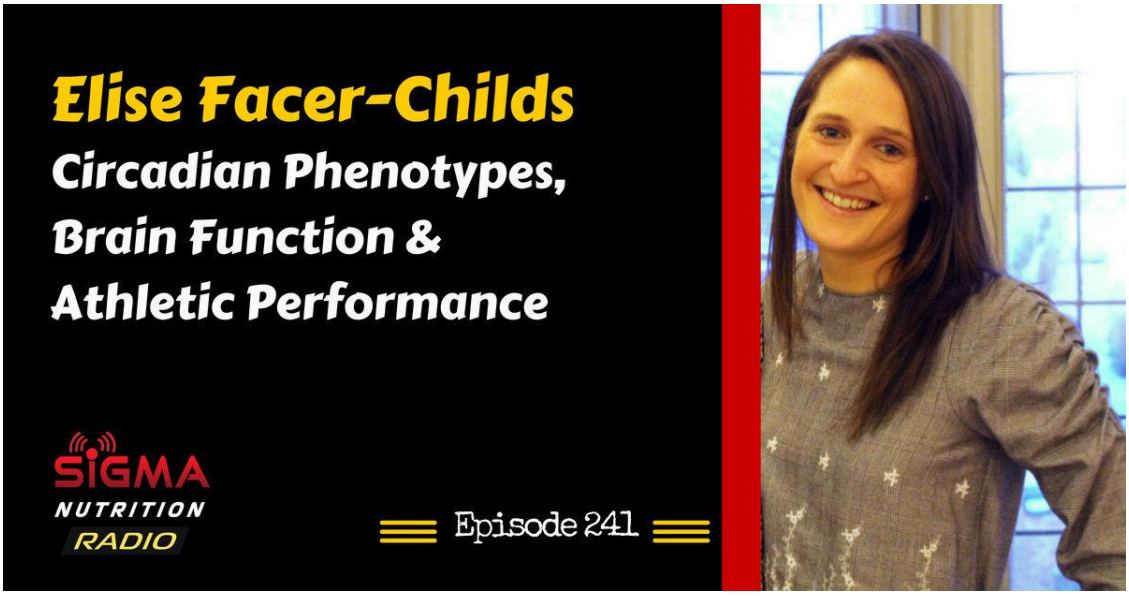

Danny Lennon: Elise, thank you so much for joining me on the podcast today. How are you doing?

Elise Facer Childs: I am fantastic, thanks for having me.

Danny Lennon: It's my absolute pleasure. This is an area that, as people who regularly listen to the show will know, I have quite passing interest in and try and learn about, but obviously been able to read some of the areas that you've been involved in, and some of the research that you've been part of has been particularly fascinating, and I've got quite a few questions that I am eager to hear your response to. But before we get to maybe some of the specifics around your research, maybe if you give people an introduction to your current work, the position you hold and your main research interests right now, and then maybe even how you kind of got that point to give some background context.

Elise Facer Childs: Yes, of course. Well, at the moment I am a research fellow at the Centre for Human Brain Health at the University of Birmingham. But how I got here is not maybe quite the traditional route. I actually never funnily enough wanted to be an academic, and yet here I am. I went to university with the intention of doing medicine eventually, and I did a degree in human biology and in my third year of my undergraduate degree I did a dissertation project on biological rhythms, and incorporating sports performance. And you tend to hear this with any sleep or circadian research, you tend to hear that whenever they first start

learning about this kind of thing, they just become transfixed. And that's exactly what happened to me, as soon as I started learning about this research and how it relates to different elements of performance, I just couldn’t get enough of it. So I decided to do a masters, which took a bit of convincing for my parents, seeing as though they didn't know what the word chronobiology meant at that time. But that just solidified it to me that this is the area I wanted to work in, so then I did my PhD, and the first half of my PhD, I think we are going to talk a bit about, that was involving athletes. And one of the biggest things that I am interested in is individual differences within the context of sleep and the word I just used, chronobiology, and chrono is a word that we use for time, I guess an easy way to think of it is another word for a watch is a chronometer, so chronobiology is basically the study of biological rhythms, and one of the most readily observed biological rhythms that we have as our sleep-wake cycle, and I am sure we will talk a bit about sleep in a bit. But I would say I am traditionally a chronobiologist, so I study all different types of biological rhythms, one of which is our sleep, but basically everything we do follows a rhythm with our hormones, clock gene – gene expression or behavior, everything follows a rhythm.

So yeah, I did the first half of my PhD looking at individual differences in these biological rhythms, and what I mean by that is we tend to get people who are more swayed towards more of a morning type or a lock and the other end of the spectrum are night hours who really love burning that midnight oil. And what I am most interested in is looking at how those different groups of people vary in terms of the behavior and their performance. What I've also done later on in my PhD is looking at how the brain is affected by this, so I've used techniques in neuroimaging, MRI scans to look at how our brain function, it differs depending on the time of day and depending on whether you are a morning lark or a night owl. So that was my PhD and now I've gone on a bit of a tangent to that in my current work because I am now looking at more clinical populations, so looking at how sleep disorders affect the brain and actually links to mental health. And I don't know if that's something that you will want to pick up on later, I think mental health is an area that is not talked about enough in our society. Lots of people suffer from mental health. And then in the context of sports and elite athletic settings, I think mental health in sports is definitely not researched enough yet. So that's sort of my area now, but still within the context of sleep and chronobiology.

Danny Lennon: Amazing. I definitely want to try and cover as much ground in all of those different areas as we can through this conversation. And I think maybe a good place to start was when you talked about those essentially different chronotypes of a morning lark or a night owl that people will have kind of be familiar with that terminology and will probably identify as one or the other. When we are talking about this, is there a good way for people to work out which one of these kind of phenotypes they are, like is it always a very clear cut thing or can they be a bit of both, can they change over certain different time, how come people think about identifying what they are in terms of a chronotype?

Elise Facer Childs: Yeah, that's a really interesting and good question, and I think it's at the simplest level, everybody is aware, somewhat aware of the kind of type that they are. Generally, people prefer the morning or prefer the evening or lots of people are in between. Some people don't like either, but that's probably because they are severely sleep deprived. But in terms of the literature, from a science perspective, there are different terms that are used depending on what you are looking at. So the word you just used, chronotype, that was developed by a colleague over in Germany, in Munich Till Roenneberg, who's developed that word and chronotype essentially is a reflection of your behavior and your sleep-wake patterns on workdays and on free days, taking into account your sleep durations and things like that.

Another term that's used in the literature is morningness-eveningness and that is determined using a questionnaire called the Horne & Östberg's questionnaire, that dates back to 1976. And that's looking at something slightly different which is diurnal preference and people sometimes get a bit confused between the two, because if you think you have diurnal preference – diurnal just means day active, so we are looking at during the day, if you ask people questions like if you had nothing else to do, what time would you get up and what time would you go to sleep. That could actually be quite different to asking somebody within the past month what time of day have you got up on workdays and what time have you got up on free days or non-workdays. And for lots of us, we are sort of forced into certain schedules because of school or work and so the sleep-wake patterns that we follow during the week are quite different to what we follow on the worked. So I think that's the first thing to say is there's a difference between what preference you are and what

chronotype you are. And those two are determined using questionnaires and they are readily available on the internet. I know the Munich chronotype questionnaire, you can just do online, and get a report to say what type you are.

If we look at it from a more physiological view, there are a number of hormones that follow, that regulate our sleep-wake cycle, one of them is called melatonin – I am sure you've heard of it, and our melatonin rhythm, over the course of the day is usually low during the day and then it rises in the evening. And one of the tests we can do to look at what circadian phenotype you are or body clock type is looking at that melatonin rhythm. So coming back to the individual differences are larks, we can actually look at that rhythm of melatonin and see very different times that that melatonin starts to rise in the evening between our larks and our night owls. But again, that can sometimes look different to your diurnal preference and to your chronotype. So what I try and do within my research is look at all of those things together, so look at your behavior, look at your hormonal rhythms and actually monitor people on a daily basis over a number of weeks. And we normally do that with something called wrist actigraphy, so they are just wrist worn devices like our Fitbits or our jawbone devices or things like that, although, they tend to be more reliable and a lot more expensive research grade. But we use a combination of all of that to be able to categorize people into an early circadian phenotype we call it or a late circadian phenotype or in between, so that's our larks and our owls.

Danny Lennon: So following on from that, seeing as there are some subtle differences in some of that terminology and you mentioned that as opposed to just preference, there can be someone's typical schedule or other requirements, culturally and socially kind of obviously affect their usual sleep and wake times, so how much of someone's circadian phenotype is driven by genetics versus things that are just outside of genetics that someone can learn to be a certain circadian phenotype? Is there any way to kind of quantify which one of those is proportionately having a bigger effect on what circadian phenotype someone maybe?

Elise Facer Childs: What a lot of the literature linking to certain clock genes – one of the most widely studied clock gene is called the period 3 gene and there is a certain mutation within that gene that links people to a morning type or an evening type, and what a lot of that literature has used is what we talked about before, the diurnal preference.

So, in terms of that, and in the context of that, I would say, maybe your preference, your innate preference to either morning or evening is perhaps more influenced by your genetics, whereas when we actually look at your behavior and your circadian phenotype or chronotype, it's influenced again hugely by your environment and the light-dark cycles that you are exposed to, and things like that. But ultimately, these individual differences are influenced by a combination of physiology, genetics and environment, there are lots of things going on and it is quite complex.

Danny Lennon: For sure, and we will probably circle back to that later on when we talk about the practicalities for athletes as well as general population folks in just a bit, but before I get onto some of your work looking at athletes and performance, you mentioned about the neuroimaging work that you've been doing in kind of recent times, can you maybe give a broad overview first of all of some of that and some of the kind of key things to make people aware of, because I am fascinated to hear exactly what you've been looking at in the area and maybe any things that you can kind of tell us what the literature seems to show in that area?

Elise Facer Childs: Yeah, of course. Well, I think the first thing to say is that neuroimaging and MRI scans, they are extremely good techniques, we know they are good techniques, they are over-subscribed at the NHS because they work, and we know we can get useful information about the structure of the brain and what's going on in the brain from these, what hasn't been done too much is using these sorts of techniques in sleep and chronobiology research. And I think that's an area that really needs some more research to be able to answer certain questions about the neuronal mechanisms behind these differences that we see. And there have been a handful of studies that have looked at a functional MRI depending on time of day. And a couple of studies have shown that there is actually a rhythm to our brain activity over the course of the day, which you could expect if you think everything else shows a rhythm and there's a time of day where we feel more sleepy and a time of day where we feel more alert, but the fact that we are showing this in certain areas of the brain now is really fascinating. What I look at, what you tend to do using functional MRI is doing tasks within the scanner. So you put somebody in an MRI scanner and you say, I want you to press a button every time you hear this sound or you see this, and then you measure those responses and you look at what's happening in

the brain. And you tend to have an idea of what you are looking for, so if you had an auditory stimulus, so you are telling somebody to do something once they hear a sound, you would be looking in the auditory cortex of the brain.

What I am doing is something a little bit different and it's looking at resting state brain function. And that might sound a little bit silly, I don't know, some people think that when we are at rest, when we are not doing anything, the brain isn't really doing anything either. But actually our brain at rest is hugely active, and to put it into perspective for you, the brain takes up about 2% of the body's weight which isn't particularly a lot; but if you look at energy consumption of the whole body, so the brain is 2% of this weight, but in terms of energy consumption, the brain takes up 20%, which is huge. So the brain is doing a lot. If you ask people to do a task, that changes the energy consumption by about 1 or 2%. So actually the fact that at rest, our brain is taking up 20% of our body's energy shows us that there's a lot of interesting information in what's going on in the brain at rest. So, the work that I've actually done is taking morning larks and our night owls and putting them into an MRI scanner, asking them not to do anything at all, just to lay there, at rest, and measuring something called functional connectivity. I know I am using lots of scientific words here, but I will explain it.

So what I mean by functional connectivity is when certain parts of the brain are known to be active, blood flows to those areas to give it more oxygen and what we measure in functional MRI is that level of oxygen within the brain. And in one area of the brain, you can see as receiving this blood flow and oxygen and another area lighting up at exactly the same time, you would say those are functionally connected. So they may not be anatomically or structurally connected and we can look at anatomical links with different type of neuroimaging, but also dissections of the brain, we can actually see that part is connected to that part. With functional connectivity, you are saying, because they are essentially active or functioning at the same time then there is a relationship there. And the work that I've been doing is does the functional connectivity of the brain at rest differ between our morning larks and our night owls, and I am in the process of publishing that at the moment, so I can't say too much but there's some really interesting results coming out of that and I've linked it to performance measures outside of the scanner. So maybe to give you a little snippet, what I am showing is how well your brain

is connected at rest relates to how well you would do in cognitive and physical tasks outside of the scanner.

Danny Lennon: Super interesting. I think we will definitely have to get you back on once more if that data is actually published and then you can talk about some of the published work. Just on that, when you are talking about this functional connectivity and looking for differences between these different circadian phenotypes, is that based on a specific time of the day that you are comparing these to or is it the same relative time for both groups if that makes sense or how are you setting up when, over the course of that day, the test actually happens?

Elise Facer Childs: Yeah, that's a really good question. You sound like a chronobiologist. That's one of the things that we did have to think about because when you are designing these sorts of studies, because you are looking at people that have very different circadian phases and sleep timings, one of the things you have to think about is do we want to test these people based on internal time which is relevant to that individual or something that we call clock time which is the time that we see on our watches or the clocks on the wall. And what I mean by internal time for example is if somebody woke up at 6 AM normally, and you tested them four hours later, that would be 10 AM in real time; whereas somebody that woke up at 10 AM, if you tested them four hours later it would be 2 PM. So even though you are testing both of those people four hours after their wakeup time, so you would say that's the same internal time, looking at real time or clock time, it's quite different. The studies that we've done, we looked at not only time of days that we did these scans at multiple different times, over the course of the day, we decided to do it based on clock time, which is maybe slightly controversial but it comes down to the fact that in our society we have these people living every day. We have morning people and we have evening people, and they are going about their days as best they can. So to make this relevant to what's going on in everyday life, we wanted to see how these people are behaving and how is their brain behaving based on their normal activities and their normal day to day routine. And that was probably of most interest for our night owls because that's the group who don't tend to fit into our nine to five schedule, they tend to have to wake up earlier than their body wants to, and then they still can't get to sleep until later, and that means they accumulate a sleep debt over the course of the week or when they are working or going to school,

and then at the weekend everybody has a lie-in and tries to catch up.

So what we actually wanted to ask is in a normal working day, a societally constrained day, how are these people behaving. So we actually did our tests at the same clock times, we did at 8 o'clock in the morning, 2 o'clock in the afternoon, and 8 o'clock in the evening, and that was the same for everybody, so we could do a direct comparison.

Danny Lennon: Yeah, that's really important. I think it's certainly interesting to see how the practical implications of this does make it more relevant to look at clock time, because like you say, if someone is in university or in office job, they can't go and pick what time they are going to go and start doing these certain cognitive tasks, so comparing it to a clock time definitely makes sense there. One of the things that I did want to ask and let me know if you can give any of these details yet or there's maybe no data to answer this yet, but if we are kind of comparing these groups and we are looking for differences, does it seem that there's going to be differences but just relative to the time of day or does one group going to have a lower baseline level or lower average level of this functional connectivity over the course of say a full 24-hour period if we are looking at the averages?

Elise Facer Childs: Also, it seems to depend on what areas of the brain you are looking at. But ultimately, what we are seeing is that some areas of the brain or some networks within the brain are affected by time of day, some are not, but overall we are actually getting fundamental differences between these two groups. So as you said, the average functional connectivity regardless of time of day is different. I mean, that's quite substantial because you are saying, you might expect our night owls to be better at 8 PM because that's the evening and our morning larks to be better at 8 AM because that's the morning. But perhaps because our night owls tend to be the most compromised, like we just said within our society, we are seeing more of a chronic effect of night owls being affected over a long period of time. And so regardless of time of day during that time period, during a working day, we do see these differences in the overall average. But that's not to say that perhaps if we had kept people awake and we had tested our night owls at midnight or 2 o'clock in the morning, we would see a difference there. But again, that wasn't a question we wanted within this working day. And you would be looking at something

slightly different and in lab studies where you can control all of these things and you keep people in constant routines for 24 hours or longer than that, you can start to untangle the effects of sleep deprivation and the differences in circadian rhythms, and that's very important for the research field. But again, as we said, maybe doing these field studies in home environments and following the normal everyday life, does give us more of an insight into how this can relate to the real world.

Danny Lennon: That's absolutely fascinating. And I guess, based on this – and correct me if I am picking this up wrong or interpreting it differently, but that would lend itself to say maybe what we are really hypothesizing there is that the potential negatives for someone who is a night owl or one of these later circadian phenotypes isn't inherent to the fact just that they are a night owl that that may not be any problem at all. It's more the circadian mismatch that occurs when they have to fit in with normal cultural and societal timeframes. And so maybe would that go to say that if we have someone who is a night owl but who maybe they work for themselves and they do get to sleep until 12 PM every day and stay up till whatever time that they may not see these same detriments as a night owl who still has to conform somewhat to these external requirements for sleep and wake times.

Elise Facer Childs: Yeah, I think that's a really important point to make. And I guess it's a double-edged sword because if we think about – yes it might be best to leave everybody to their own devices and I think in terms of our working society, we should be more flexible for our workers, in terms of what we can see for productivity and performance when you have optimal sleep, an alignment of your biological clocks, we know that that increases performance and productivity. So, maybe there would be a real benefit in allowing people to follow their own sleep cycles. The other side of it is how important light exposure is, and I know you've probably covered this before in previous podcasts, but light is the strongest entraining factor or Zeitgeber, that comes from the German, it means time giver, and the light-dark cycle is the most important thing that helps our bodies tell the time from the inside. So when the sun comes up every day, there are certain cells within our eyes that register that light and tell our brains to wake up. And again in the evening when the sun goes down, those signals stop and basically tell the brain that we need to start preparing to go

to bed. And we know that getting light exposure at the wrong time can have negative implications.

So the other side to your question is if we let all the night owls wake up at 12 and go to bed at 3 AM, are they limiting their natural light exposure and what effect will that have. So which one is better? And I think maybe there's not enough research into that, especially the longitudinal aspects of it, because we are not talking about a couple of weeks here, you can readjust to jetlag within a few weeks, but we need to do much more longitudinal research to see which one of those would be best. And maybe the happy medium or the compromise is working with people, firstly increasing awareness and getting people understanding more about their biological clocks and their sleep I think there's a huge stigma in our society of night owls being lazy, and it's not that they are lazy. There's biological predispositions and you are forcing people to go against their body every day so no wonder they want to wake up later and later.

Danny Lennon: I just think that's a really important point that I want to reiterate because I think there maybe the temptation if we are to say, well, some people are just night owl and they are just set up that way, then it's very easy for someone to sit up on a laptop or watching TV until all hours the morning and just say, well I am a night owl, this is just what I prefer to do, and that necessarily probably isn't a good thing for your circadian rhythms anyway. So I think that's a very important point that you made that we have to be careful of how far we can kind of push this kind of conclusion around where people are going to or what their kind of, the optimal setup for light and dark exposure and sleep and wake cycles actually is. And that probably ties into I guess how modifiable this chronotype is and how adjustable it is and what that adjustment period might look like and if we have someone, who is this kind of night owl, can we do certain things that will entrain them to an earlier type of chronotype that is, like you say, that kind of happy medium.

Elise Facer Childs: Yeah, absolutely. And I think what you just said, with the stigma and it would just add fuel to the fire, with people assuming that these night owls are lazy so it makes the night owls think, oh yeah, well, I will just stay up later and I will do this and I will delay my sleep. But again, bringing it back to, if people are aware of it, of the implications, that's one thing, but then having the tools to be able to do something about it. And I think that's what is really important that we need to do more of is develop strategies and

ways that we can help people, either get – well, basically get to that happy medium.

Danny Lennon: Elise, I've loved talking about some of the stuff and I probably overshot how long to spend on that segment, so before we do start wrapping things up, I am keen to get to those two other areas that you mentioned at the outset, even if we are to give a kind of overview because I think they are both equally fascinating. If we turn first to some of the stuff related to athletic performance, I know you've been involved in a number of things in this area, what are kind of some of the main conclusions you would take from some of that work, maybe you can outline again an overview of some of that work you've done in the area of what questions you were trying to answer in relation to chronobiology and athletic performance and then some of the principal findings you have today.

Elise Facer Childs: Yeah, absolutely. Well, what a lot of previous literature has suggested is in terms of athletic performance is the peak performance occurs in the early evening between about 6 and 8 PM. But what a lot of these studies didn't do is actually account for a control for individual differences, what we've just been talking about for the past half an hour. And so some of my earlier work was looking at answering that question, does peak performance in athletes differ depending on whether you are an early bird or a night owl. And to do this, we basically recruited I think about 120 athletes, we did this chronotyping so we could categorize them and then we took a subset of them and tested them at six different times a day. What we are were looking at is cardiovascular endurance, we did testing from 7 o'clock in the morning, every three hours, until 10 o'clock in the evening, not on the same day, because they were running to exhaustion, there would be a number of issues there. But what we found was actually really fascinating because with this previous view of peak athletic performance occurring in the evening, going along with the circadian rhythm of cold body temperature that we know rises in the early evening. So there was a lot of work to link that. What we found is when we group everybody together, so we've got our larks and our owls and those people in between that we call intermediate types, we get pretty much exactly what all of the literature said. So we had a really nice diurnal over the day profile of performance with peak cardiovascular endurance occurring in the early evening between about 5 and 7. It was crazy.

But then when you actually split these groups out into their respective groups, so we had our larks and our owls and our intermediates, what we saw is something that was quite different. So our morning larks actually did their best at around midday and our intermediate types at about 4 o'clock in the afternoon and our night owls, not until 8 o'clock in the evening. So what we actually saw is that by grouping everybody together, we skew that and we see that early evening peak but actually they are quite different. And given that we do have a lower percentage of morning larks within a general population, you normally get about 10% and a much higher proportion of intermediate and late types, that is higher, in the athlete population you do get more early types. But that could be one of the reasons why we were seeing that evening peak in performance was because we are grouping everybody together so those earlier peak times that we see in our morning larks were being missed.

The other thing that we found in that study that was quite stunning was the variability in performance over most of the day. And what we found is that performance could vary by up to 26%; and if we think about, in the athlete elite performance settings, 1%, even less than 1% can make a huge difference, everybody is seeking those marginal gains. So the fact that we show a 26% difference in performance and that was in our night owls which you would maybe expect because they are the most compromised maybe during the morning hours. And our early types or morning types or early birds, their variability was about 10 or 11% I think. So much higher in night owls, but even that, even 5, 10, 15% is huge if you are looking at elite sports.

Danny Lennon: Yeah, that's just pretty fascinating, I found that amazing, like you say, that's just an absolute phenomenal difference in performance, especially given how much we try and work for those very small changes. And it's really cool to see something that has actually looked to see those individual data points or this distribution pattern rather than looking at an average that gives us this time in the evening is when people's performance peaks. One question I did have around that is like you say, there's not a huge amount of research done in this area and I know you mentioned that you looked at performance with the cardiovascular test – is there any research or suggestions of does this – these types of results, would they still persist for other performance metrics or other type of testing in different domains,

outside of say cardiovascular tests or do we have any ideas or hypotheses on that?

Elise Facer Childs: Yeah, that was what I wanted to say next actually, so you read my mind. I think yeah, one of the most important things that we do need to do within, not just this field but performance in general is how we define performance, it's so complex and there are so many different ways that you could define it and we use that word, because it's nice and it's general and everybody kind of knows what you are meaning, but yeah, we look to cardiovascular endurance but that doesn't mean overall athletic performance does follow that same profile. And that's exactly what I've been doing over the last couple of years in collaboration with the School of Sport and Exercise Science at the University of Birmingham, supervising students to specifically look at other measures of performance, because especially the athlete population, getting athletes to their best, not just physically, but also mentally, cognitive capabilities are extremely important as well for lots of sports.

So we've been looking at a number of different other measures to be able to see whether we can replicate these results, and some of these are just basic reaction times or psychomotor vigilance, looking at grip strength, executive function tasks, things like that. And again, I am just publishing that at the moment, but we tend to see very similar profiles over the course of the day, so that we do get differences between our night owls and our morning larks and also the variability again is quite different, not up to 26% I think what we've got is around 12%, but still, as we said, that can be considerable within sport settings. So it looks like you do see these differences within other tasks, there has been other research as well, I know in swimmers and there are other groups looking at this. So we are starting to realize that there are different performance profiles between our morning larks and our night owls, but again doing this more whole rounded approach to looking at performance, taking into account lots of different measures is extremely important, yeah, going forward.

Danny Lennon: Yeah, for sure. And I guess, given the questions that still remain and the future areas of research to explore in this area, right now what would you feel are the main practical implications for athletes and coaches listening to this in terms of – I mean, the immediate ones that probably jump out to people is if they are an individual who say can control their training time, is that

something they should look at? If they are an athlete who maybe can control when they have to train, maybe they have a fixed time, what should they go about doing? Is there any practical advice you would put forth to athletes and coaches that the literature can inform at least at this point in time?

Elise Facer Childs: Yeah, I guess, there's a few things. Firstly, it's increasing your understanding, so I know a lot of elite sports are now taking account of sleep, and that's extremely important, getting the right amount of sleep, and the right sleep quality at the right times, and all of that, but increasing our understanding of perhaps the chronobiology side of things. We like to go towards this one size fits all, we all need this amount of sleep, we should all sleep then and we should do this and train then and do that then, but where I would come from is that it's hugely individual. And being aware of within a team or certain athletes, for coaches, learning about how these differences could be affecting your athletes, also from a psychological perspective, just a relationship between a coach and an athlete or a manager, if your athlete always turns up in the morning and seems to be really moody and that affects the relationship, if you understand that maybe that person is a night owl and they are being forced to do this, so maybe their performance is being affected, then it could change the relationship and have a positive impact on their psychology as well as all of the other science that we are talking about.

So firstly, increase your understanding. Secondly, I think, in terms of being able to adapt training schedules, that's definitely something worth looking into. I mean, if you have flexibility over that, there's no point – for example, say you have a night owl and all of their competitions are in the evening, is there any point in getting them up at 6 o'clock every day to train? The flip side of that is you have a night owl and they have morning competitions. What do you do about it then? And I think that's where we can really bring this research in and that's one of the areas that I am looking into and doing at the moment and that's whether we can advance, so make night owls earlier and what impact that has on their performance as well as their psychology. Well, you can do that and I am seeing some very promising results, but I think it comes down to the fact of really getting to know what is going to be best for that athlete based on how they normally sleep, how they want to sleep, their training and competition schedules and then any travel. It's taking all of these things into account to be able to get the athletes to their best at the right time.

Danny Lennon: Yeah, for sure. And I think there are some really important considerations for the coach-athlete relationship like you mentioned, which I don't think – at least I've heard really anyone else directly talk about that in relation to this topic. And I think it shows the layer of complexity that we shouldn't just consider these first order effects but there's these second order indirect effects that we can have through understanding this whole area more. So I think that's an extremely important point and certainly one I don't think has really been talked about all that much. The second part that you mentioned around essentially changing maybe or shifting that kind of circadian phase depending on when the event or tournament or competition is on, presumably is that something that you would see similar to what athletes may do if they are changing time zones to account for jetlag, not only changing their wake time but their light exposure, melatonin supplementation, all these different things to try and shift them maybe in the days or weeks leading up to competition to put them in that more optimal zone, is that what we are kind of talking about there?

Elise Facer Childs: Yeah, partly. I would say that there are these tools out there like changes in light exposure and melatonin supplements and things like that, which we know can be very useful. What needs to be done and you need to be very careful about is the timings that you do these things and like basically what we've discussed throughout this whole podcast is these individual differences. And if you are giving someone melatonin or exposing them to natural light at a different internal time, it could be the same clock time, you give someone melatonin at 6 o'clock in the evening to help them sleep, if you are giving that to a morning lark and a night owl, it's completely different internal times. You could actually be – that could be detrimental because it could help somebody get to sleep, but then if it doesn't allow them to wake up in the morning, then you are affecting to whole next day. So, thinking about those knock-on effects, it's the firsthand, okay we need to help somebody sleep, so we need to put these things in place to help them, but then what's going to be happening 24 hours later, what's going to be happening next week if you've affected them on this day?

So I would say that having the expertise or the advice from somebody that knows about all of this stuff and maybe you can profile your athletes so that you actually know who's who and

when to give what when, I think we are all going down towards personalized and individualized medicine in terms of, in this field anyway, and generally giving certain drugs at certain times of day because drug metabolism is affected, so it's better to give certain things at different times of day. But perhaps, that within elite sport settings as well, so individualized schedules or administration of things, I think should be where we are going. I realize that that might be quite difficult, but yeah, as I said, I think the first stage is actually trying to get people thinking more about this, not just the sleep side but the chronobiology side.

Danny Lennon: Yeah, for sure. Elise, I could talk this topic for hours with you because I find it so interesting, and I know we still didn't manage to get over and cover the interesting clinical applications you've been talking about and that you are doing work in, so we are definitely going to have to get you back on the podcast if you are up for that and go in-depth there, because I have so many questions that I could ask, but we are going to have to start wrapping things up here. So before I get to my very final question, if there's people that are looking to read up more about your work, maybe look for research profile or find you on social media, is there anywhere online you can direct them if they are interested in getting more information about you or about this topic?

Elise Facer Childs: Yeah, of course, so I've got a ResearchGate profile, yeah, my name Elise Facer Childs. I am also on Twitter at facerchilds, and I've done a number of public engagement and media things that you can find online. Again, we talked about a couple of things that I am hoping will be published soon, so keep an eye out for that. And yeah, until next time, I mean, I could talk about this stuff until I fall asleep literally.

Danny Lennon: Yeah, for sure, we will definitely set up a round 2 and hopefully at that time some of that data maybe published and we will definitely bring up some of your work, looking at the clinical applications and mental health because that's a whole area that I think could be a great conversation, so we will definitely set up a round 2. For those of you listening, everything that Elise just mentioned, I will put a link to in the show notes, so please go and check those out. And with that we go to the final question that we always round out the podcast on Elise, this 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 a

positive impact on any area of their life, what would that one thing be?

Elise Facer Childs: It's being aware, not just about the things that we've talked about, your sleep and your rhythms, but just being aware of your surroundings, knowing what works for you, because how somebody runs their life isn't necessarily how you should. And that's not just when you sleep and when you do exercise and things like that, when you eat and when you socialize, so just being more aware. And I guess, ultimately doing something that makes you happy and that you are passionate about, I mean, I am very lucky to have found my passion and if you haven't found it yet, just keep striving because once you do, it's pretty great. And if you study sleep, you can also manage to be more productive in certain ways.

Danny Lennon: For sure, brilliant, great way to finish this out. With that Elise, I want to say thank you so much for this great conversation, I really, really enjoyed it, I've enjoyed digging into the work that you produced as well, and I appreciate you taking the time out to come and talk to me today.

Elise Facer Childs: Absolutely no problems, thank you very much for having me on.

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