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

Erica Goldstein: I am doing excellent Danny, I can't thank you enough for having me on your show. I've been listening for years and your show and all the amazing people in this field that I've listened to have really contributed both to my education and my career, so I am honored to be here.

Danny Lennon: Yeah, and I think off the back of that, when we were kind of talking over email and you were able to talk me through some of the work that you've been involved in, both in the university as well as kind of some presentations you've done, and I've found it extremely interesting because it's an area that is extremely important to a lot of people and a lot of athletes, especially to a lot of nutritionists who will be listening to this. But there's probably a lot of things that haven't been covered in adequate detail on this podcast yet, so I think it will be quite a novel discussion too. Before we get into any of that cool stuff, maybe give people some context of you, your background, and the work that you are currently involved in.

Erica Goldstein: Sure. When I finished my master's degree in exercise science I knew I wanted to work as a sports dietician. So I went and completed a didactic degree in nutrition and then did my internship, became a registered dietician and I was very fortunate to, right out of my internship, be hired at the Mayo Clinic which is where I did my internship and it was there that I just, I gained

amazing clinical experience. But at that time, I also developed this really wonderful relationship with the sports medicine team there, and we together developed the sports nutrition practice at the Mayo Clinic site that I was at. And that was just really excellent experience because I saw athletes anywhere from 12 years old all the way to your 60-year-old plus endurance athlete. And not all these athletes were healthy, so it was a constant challenge, I never knew what was going to walk through the door and those experiences are carrying me through my doctoral degree now. So just to explain, I just now finished my first year of my doctoral program and I was just at NSCA, as I think you know, doing this talk on exercise associated iron deficiency, which we are going to cover today; but I was also awarded a grant to explore relationships between a parents' level of sports nutrition knowledge and then how that may affect an adolescent female athlete's level of sports nutrition knowledge as well as maybe I want to look at also parenting style in behaviors and how that might affect the adolescent athlete, because that's just based on my own anecdotal experiences in my private practice. So that's going to be the next thing I am going to start working on. I am also wrapping up a smaller review article for the Strength & Conditioning Journal because I want to continue to help practitioners understand physiology of female athletes and so that paper has been covering energy deficiency in combination with iron deficiency and how that affects female athletes' bone health. And then we have some studies going on in a lab of a supplement nature so that's sort of what I am doing now.

Danny Lennon: Awesome. And like you say, plenty of stuff that we are going to get into in today's episode. We are going to talk about exercise induced anemia like you mentioned and kind of these related topics of iron deficiency, iron deficiency anemia and then of course specifically we will be looking at this exercise associated anemia as well. Just so we are kind of clear on maybe some of the definitions and distinctions between some of those terms, what's the best way for people to view those things or define those things in their mind?

Erica Goldstein: Yeah, that's a really good point, because I feel like even when I was a nutrition student, these terms become very thrown around and very interchangeable, and you kind of never really have a grasp of what they mean. So iron deficiency simply refers to inadequate body iron source. And so what that means is iron is absorbed through your small intestine, so your enterocyte is that

cell in your small intestine where you absorb nutrients and pass them onto your bloodstream. So you absorb iron into your small intestine and it can also be stored there for a little bit, but iron is also stored in your liver. And then finally, red blood cells that are aging, they turn over and the iron that was in those old red blood cells can now be stored in the spleen. So iron deficiency basically means low iron stores in your liver, your spleen and then of course iron is used in your bone marrow for new developing red blood cells. So iron deficiency just essentially means low body iron stores. Now, if this continues to happen over time where you have decreased iron stores, then ultimately, you are going to develop iron deficiency anemia. And that means that you really have depleted iron stores, why that's a problem is because there's not enough iron for developing hemoglobin.

Danny Lennon: Obviously, we have some distinctions here between our deficiency and then when that progresses as far as anemia. So when it comes to a diagnosis, how is that typically done for someone to be diagnosed with iron deficiency anemia and maybe more interesting to maybe a lot of athletes and coaches out there, are there some typical symptoms that tend to show up even previous to the actual diagnosis taking place?

Erica Goldstein: Yeah, that's a really good question, because it can get a little confusing, because in research studies in particular, we see a lot of iron being determined by ferritin size, and ferritin is a marker of body iron source. There's a couple of issues with that though. The first is there's no sort of – I don't want to say there's not strict guideline but when you look through different studies, they use different levels or different ranges of ferritin to determine iron deficiency and then anemia. So it can be a little tricky. Also, in a clinical setting, ferritin is sort of falsely elevated or increased because it responds to inflammation. So it's not always a good marker, and then of course with athletes, you say, okay, well, the athletes are not in a clinical setting, but what happens after a high intensity bout of exercise, you have inflammation. So while it is absolutely a marker of body iron store, it's not one that should be used for diagnosis or diagnostic properties.

So what I try to tell people is you really have to look at where iron is used and that's used in hemoglobin within the red blood cells. So, really you want to have a level of hemoglobin, right, because if hemoglobin is low, then there's not a good supply of iron for new developing red blood cells. Also, hemoglobin is what gives the red

blood cell its color. So a red blood cell that's light in color, again is not going to have adequate amounts of hemoglobin. So it really comes down to sort of the amount of red blood cells that are in a certain sample of blood and how much hemoglobin is contained within those red blood cells. There's other records too but really once you are a sports meds physician or something in that nature, you are not going to be looking at this. But certainly there are sports dieticians, maybe athletic trainers, people out there that do have access to these labs and so it's good to just be a little bit familiar. In terms of, symptoms, well, think about how you feel if you don't have enough oxygen. So you are going to have shortness of breath, and it's not just fatigue, I mean, it's that extreme lethargy, your legs just sort of feel like bricks. And then, so shortness of breath, palpitations, things like this where you just feel like I cannot get out of bed. And then those are symptoms that need to be explored.

Danny Lennon: So if we are starting to think about athletes and how this is not only induced sometimes with exercise or at least we can talk in a moment about the risks within athletes themselves, but when it comes down to the effect on performance, there's probably kind of two sides to the coin in this question. First on how does actually an iron deficiency or just low iron status impact performance; or to think of that in a different way, why is iron so crucial for athlete performance in the first place?

Erica Goldstein: So this I really like sort of helping people understand, because if you think about this in terms I just gave you, we tend to think about iron deficiency in VO2 max, oxygen use. And while that certainly is impaired, iron deficiency also affects an athlete's ability to generate ATP and thus have sufficient amounts to support multiple hours of exercise. And so what I tell people is that how iron deficiency sort of negatively affects endurance performance, well, it decreases a couple of big terms, muscle tissue oxidative capacity and cytochrome activity, it refers specifically to Kreb cycle, electron transport activity which takes us all the way back to understandingphysiology. But how that impairs performance more importantly is it takes a lot longer for your athlete to get from point A to B is what I tell people, it slows them down.

And now again, in terms of anemia, that's going to negatively affect an athlete's performance because we don't have enough iron to generate hemoglobin, so now we are going to decrease

oxygen transport, and so overall, your athlete is going to have a decrease in their overall endurance capacity. And so, really if you are thinking about endurance athletes and they are competing in triathlon or a marathon, I mean, there's no way they are going to be able to generate enough energy to – I mean, they are going to be placing really like last, they are just not going to be able to generate enough energy to supply multiple hours of exercise, either because of the effects on cytochrome activity and the Kreb cycle and then as well as oxygen capacity.

Danny Lennon: One other thing that I wanted to ask about that I think came up quite a lot when I was looking at this area of work that you've been involved in is hepcidin, this hormone or protein – but more specifically what should we know about hepcidin and what is its relevance to this discussion?

Erica Goldstein: I think this is so interesting, because it is really relatively new research. And so, hepcidin is a hormone that's produced and released in the liver. And we really know about it because of what goes on in clinical setting. And that's because most people with chronic inflammatory conditions, something like chronic kidney disease or anything that we are being admitted continuously to a hospital or being treated for something, you have a certain level of inflammation. An inflammation is what triggers hepcidin. And so, it was really smart that exercise scientists thought to take this concept and look at how this might be involved in athletics because for so long we are trying to figure out why is it such a high prevalence for iron deficiency and iron deficiency anemia in sports, especially for female athletes. And so, a couple of things were thrown around, so it used to be, we talk a lot about hemodilution because with endurance exercise in particular or training adaptation, with endurance exercises, an increase in plasma volume. You have to have that increase in plasma volume to support heat dissipation, continue to deliver nutrients and oxygen to muscle and so forth.

And so, we think that there was an increase in exercise associated deficiency but it wasn't true anemia or deficiency because the amount of red blood cells that are available, still have adequate amounts of iron, it just seems decreased relative to that increase of plasma volume. So that's really not an issue, that's not a true iron deficiency and/or anemia. So then the idea of hell strike hemolysis that simply refers to the damage to red blood cells that occurs with that chronic repetitive foot striking from running and

so that damages or ruptures the white blood cells, or release of hemoglobin into the blood stream, that iron is captured and it can be recycled for new developing red blood cells. So finally, exercise scientists were like, hey, athletes have inflammation, what if they are also having hepcidin response? And so over the last, I would say, 10 years, this has been researched and what we know is that with exercise, immediately after a bout of exercise, so high intensity, and/or, high intensity that involves chronic repetitive foot striking, you are going to see an immediate increase in something known as Interleukin 6, and it's that Interleukin 6 that spikes or stimulates that release of hepcidin from the liver.

Danny Lennon: If I have it correct and please correct me if I am wrong on any of this, when we are talking about hepcidin, basically it's playing a role of trapping iron into the cell.

Erica Goldstein: Yeah, so that's where I was going to go next. So what happens is we have this release of IL-6, then that stimulates three hours later, you see a peak in hepcidin. And what hepcidin is going to do is it's going to bond to its receptor where iron is stored on the spleen, at the enterocyte in the small intestine and on the liver, and it is going to destroy that receptor. And so, basically what you said is exactly right, now the iron is sequestered or its trapped in cell and it's temporarily unavailable to be used to generate energy in the muscle tissue and in the bone marrow for developing red blood cells. You sort of have this transient decrease in your body's ability to use iron, and it sort of sounds very negative but you have to understand it's really a process that evolved because your body is trying to protect itself because iron can actually be very toxic to the body and remember pathogens and things that cause infection utilize iron to proliferate so your body is saying, hey, there's a lot of iron that's being flooded into the bloodstream now, let's try to protect ourselves, let's trap it. But there's nothing – not any sort of feedback loop that's saying, hey, no, no, no, it's just from exercise, it's okay, your body needs it. You are going to spike IL-6, you are going to have the spike in hepcidin, you are going to trap iron, then you are going to have this transient decrease in your body's ability to use it.

Danny Lennon: Yeah, there's like plenty of different things going on here that are causing some of these issues. So first you had mentioned about this heel strike hemolysis and that itself is causing like damage to red blood cells, we also have the Interleukin 6 being elevated due to this kind of inflammatory response via the exercise, we are

having this release of hepcidin, this is causing some of the iron to get trapped and basically it's not being then able to be used, and then all those functions you talked about that we need that for during exercise are going to be impaired or not be able to occur. So lots of things going on, particularly as it seems from endurance exercise given that you mentioned things like heel strike hemolysis and that consistent pounding tends to play a role there too. So I just find it completely fascinating, there's all this stuff going on beneath the surface.

Erica Goldstein: Yeah. I agree and that's why I've been – sort of all my free time was spent really digging into this and reading any research I could find, because it is, I have to give credit to Dr. Peter, I think he's out of Australia – him and his lab have done a bulk of this research and so I sort of read anything I can get my hands on because the situation is so complex, and I just think people need to be aware of it. And because it's new, it's sort of a working theory and we are still learning how to apply it because what some of the research has shown is that those hepcidin levels will return to baseline in about 12 hours; but about three hours after exercise any available iron might not be available for use. So really how we apply this because if you think about the tenets of sports nutrition, we are already trying at times so many things, carbohydrate after exercise for glycogen, protein for muscle protein synthesis, now we've got to try to figure out when our body is not going to be able to use iron as well. So, it's fascinating, as we figure out this physiology and try to apply it in the actual athletic setting.

Danny Lennon: Sure. I definitely want to get into some of the nutrition considerations around this in just a moment, but one more thing I wanted to ask about a term that I wasn't that familiar with and I came across in some of the work that you had sent onto me and I had the pleasure of reading and it was this idea of dilutional pseudoanemia. Can you maybe explain that concept for people and again its kind of role in this conversation?

Erica Goldstein: Yes, absolutely. Well, I would say, it's kind of hard without an image; but when I do try to show an image and explain it, I still see people confused. So just sort of, as I mentioned, a training adaptation for endurance athletes is an increase in plasma volume. And so, plasma volume simply refers to that watery portion of your blood. And this is a really good training adaptation because especially in weather that we are having right now,

especially here in Florida where I am, it's very hot and humid, we really need to be able to maintain that plasma volume. And that's because that helps to dissipate heat and I am trying to keep it simple, also continue to deliver oxygen and nutrients to work in muscle, also we have to maintain that stroke volume, so this is an adaptation that occurs in hot weather.

So eventually what happens is if you look at a blood sample, red blood cells in that sample are going to seem low. And so you might be quick to say, oh no, this athlete is showing signs of iron deficiency, but it's not a true iron deficiency. That sample of red blood cells looks low because it's relative to the plasma volume that's increasing. But if you actually look at those red blood cells, there's still a sufficient amount and they still contain an adequate amount of iron within them that is going to be used for energy and delivering oxygen, etc. So it's just sort of, you have to be really careful, athletes maybe who are seeing physicians that are in sports medicines are going to be quick to tell you, oh your iron level looks low, but you have to understand as an athlete how to do this for yourself. If you know that you have a diet with adequate amounts of iron in it, and understand what's been going on with your training volume and intensity, and sort of able to say, no, I think it could just be from this phase that I am doing in my training cycle in the heat, because it could just be dilutional anemia.

Danny Lennon: Yeah, sure. So it's essentially the case of the absolute amount of red blood cells is perfectly fine but just because we are getting this increase in plasma volume due to whatever kind of training phase they are in, the concentration is just thrown off so it might be flagged on a test, and like you say, if the athlete is aware of that, they can mention that to their doc and also probably base treatment on multiple tests as opposed to just one time after a particularly tough run of training as well.

Erica Goldstein: That's absolutely correct, and I couldn't have explained it better. As I mentioned, a doctor Dr. Peter has done a lot of work in this area, and a couple of papers that just came out had some pretty significant results, and this is really the take home or the big picture moment, I want people to understand is that there are about four factors that really affect that hepcidin response. And so that's your baseline iron status, so your baseline iron source, the amount of iron that's just in your blood, that post exercise IL-6 response and then exercise duration, because exercise duration

intensity really seemed to magnify that IL-6 response. So you have those four factors taken together as a composite that really affects the hepcidin response. But then, when you look at each factor individually, it's your baseline iron stores that really seem to be the most significant factor that affects this hepcidin response. And why I am mentioning that is because if you don't properly screen and monitor your athletes over, I would say, the course of a season, the issue is going to be these athletes that are sort of in this sub-optimal group, meaning their serum ferritin which is a marker of body iron stores, well, they don't have iron deficiency but it's not particularly high either, it's not really moving in the right direction. So over time, if they keep having this hepcidin response, they are not getting enough iron in their diet, if it's a female athlete, they are not getting enough total calories in general, these sort of things start to go on, then this is going to be the group of athletes that's really going to move into this place of iron deficiency. And so I think that that's sort of the take home message of all of this is that that's why we have to monitor athletes because you could do a test and you are like, okay, your stores are fine, you are not iron deficient, but if they are sub-optimal that's still going to be a problem, and those are going to be the athletes that are at the highest risk for really moving into and developing iron deficiency.

Danny Lennon: If we are then to move from that, so based on those things and especially given that you said the importance of baseline levels, when it comes to, I suppose, some of the preventative measures first, before we start talking about how to address this, from a kind of prevention standpoint, there's probably some fundamental things with the diet we should promote with athletes, what are do you think some of the most important that they should be aware of or at least be trying to do with their diet from a preventative viewpoint so this doesn't end up being an issue?

Erica Goldstein: Yeah, okay, so I would say, the first thing is let's say talk about the different sources of iron in anyone's diet. So, we have plant based iron and we have animal based iron. So which would be iron that comes from meat and iron that comes from plant based sources, such as nuts or seeds, vegetables. So, the issue with iron that comes from plant based sources is that it presents in the form of iron that's not readily absorbed. And what I mean by that is as you probably know, and hopefully most people know, nutrients don't just move in and out of a cell freely, most nutrients have to have

some sort of transporter that actually guides them into the cells. So glucose is an example of that, it needs to go through glucose transporters, from the blood into the muscle cell, fructose at the level of the small intestine that has to fire the transporter that moves it from outside the small intestine into the absorptive cell.

So iron is no different, iron has a very specific transporter that will take it from what you eat in the diet and move it into your small intestine. And so that transporter requires iron to be in a very specific form and that's known as ferrous. The type of iron that is present in a plant based form is not ferrous, it's known as something else. So now we need to reduce or for simplicity convert it from something that it can't be absorbed as into something that it can. And so most people have heard that plant based sources usually consume it with Vitamin C, and that's the reason, because Vitamin C helps convert it from something your body can't absorb it as into something that it can. And so, that all works fine, but you have to understand, because it's not as readily absorbed, you need to eat a lot more of plant based sources of iron to get what you need.

So, animal based iron or meat based iron is a totally different story, it's pretty much absorbed into the cell intact, it's then broken down and then the iron is readily available for you. So that's the difference between the two, it just comes down to bioavailability. There's also something that you learn as a nutrition student or something called the meat-fish-poultry factor, and that's kind of interesting, because this meat-fish-poultry, so basically if I eat lentils, lentils are a great source of plant based iron, but because it's not readily absorbed, if I am not a vegetarian and I eat lentils and add some chicken to it, the chicken is really going to help your body absorb the plant based iron. So that's sort of a trick when we are trying to increase iron in people's diet.

Now, I am not saying that vegetarians can't meet their daily iron needs, I am not saying that at all. I am just saying, they need to eat a lot more of it so that they can adequately meet their needs, and that's why people who eat both plant and meat based sources of iron, so female athletes in particular, they require 18 mg of iron a day, and vegetarian athletes are going to need almost two times more, so about 33 mg.

Danny Lennon: Outside of the direct iron consumption that someone may have to try and keep on top of, keeping their iron status high, are there other factors within the diet that may influence this, particularly if there's already say established iron deficiency or low iron, so things like the overall energy of the athlete's diet, their carbohydrate intake, micro nutrition, how do those things influence some of this picture when it comes down to eating to maintain adequate iron stores?

Erica Goldstein: Well, yeah, first and foremost, if you are just not eating enough and there's certainly no shortage of studies to document female athletes eating way below what they need, and what I mean is, so if you think about an athlete eats enough calories, total calories to support, like we said, muscle protein synthesis, glycogen repletion, iron for developing red blood cells, so we need to eat enough calories and then of course athletes need specific amounts of carbs and protein and fat. So if you are just not eating enough, you are not going to get enough iron for what you need period and overall that is going to lead to a chronic energy deficiency and micro nutrient deficiency, but also remember athletes on top of just what they need to function, they need enough calories for exercise energy expenditure. So we need iron to produce energy. So if you are just not eating enough period regardless of what type of diet you are on, you are going to develop multiple issues and one of them is going to be a micro nutrient deficiency like an iron deficiency.

And there are other intricacies to be considered, so when you are eating an iron based meal, you preferably don't want to drink something like tea with it, because the type of nutrients that are in tea are going to bind the iron so that could lead to decreased absorption of iron. And then calcium can also bind iron so that can lead to decreased absorption. I tend to not talk about these things as much because like I said, when it comes to athletes, there are already so many things that we are timing. Like I said, the glycogen, the protein, now we have to make sure we have Vitamin C sources, with plant based iron sources if the athlete is vegetarian, and then of course dairy for most athletes is a really big staple in their diet. So I try not to make things as confusing as they can be for athletes and try to focus on the bigger concepts, but I mean, if possible, for a milk drinker, I may have milk as a supplement, you can sort of use as a supplement after exercise and not drink it with it so that does interfere with any plant based iron. Same with ice tea, it's really easy to drink and rehydrate with

water after your meals and if you are a tea drinker, drink it in between meals. So those are pretty easy fixes. And when I am working with an athlete, I try to start simple and then if they are incorporating those concepts, then we can be a little bit more intricate with how we are managing their diet.

Danny Lennon: When it comes then to the role of supplementation and specifically if you do have an athlete who you either suspect or who has been diagnosed with low levels of iron, when it comes to supplementation, obviously there's going to be some individualization required, but from just a general overview point, are there some general guidelines you would give in terms of dosage to be used, specific type of iron supplement you'd recommend, if there's any particular brands, even on top of that, what are some of the general guidelines you may give to athletes?

Erica Goldstein: Yeah, so that's a really good question because we have to be really careful with supplementation and actually a lot that's also very new, a lot of good studies are coming out in regard to supplementation, because you have to remember if you are taking in an iron supplement and you don't need it, over time, if you keep doing this, you already have adequate body iron stores and now you just think you are going to take a supplement of iron because you think you might need it, and you are not really well-informed, the problem is your body is going to store that iron and has no way to get rid of it.

Now, of course, we lose a little bit of iron on a daily basis through sweat, urine, also those enterocytes that we are talking about in the small intestine where you actually absorb nutrients, those turn over about every two to six days, and then women are going to lose a little bit blood, a little bit iron in their blood during menstruation, but really for the most part, your body has no way to get rid of excess iron source. So it's going to be stored in places like organs where your body doesn't need it and then eventually that can lead to organ damage, so heart failure, liver failure. So you have to be really careful about just, while listening to talks and reading things and thinking that you need an iron supplement and you don't, because it can be very damaging to your body. So that's one aspect.

The second thing is if you actually are iron deficient but you are taking in a supplement where the iron is fairly high, well, this is going to bring us back to the beginning of this talk and you are still

going to get a hepcidin response, which is going to be counterproductive. So what studies are really recently showing us is that smaller dosages are a lot safer and productive. So, anything that's about between 40 and 80 mg, and so that's elemental iron, so elemental iron is what your body actually absorbs and utilizes, so I don't really like to talk about [inaudible 00:41:02] I would say that you want to make sure that whatever you are using, especially if you are an athlete, it's cleared by something like NSF or Informed-Choice, any of those. But most iron supplements, for example might say on the bottle 325 mg of ferrous sulphate but you are really absorbing the 65 mg of elemental iron. And so anything in that 40 to 80 mg range is probably going to be not only the safest but it's going to keep you from having that hepcidin response. And right now, literature is also showing that maybe taking iron on alternate days is also going to help you avoid the hepcidin response instead of daily, but then we get back to this whole concept of having to individualize nutrition for the athlete. When you have someone that you tell them to take iron on alternate days, and they are kind of not typing and they don't track it and now they are like they took it yesterday, they took it two days ago, so if that is going to prevent the athlete from taking the iron supplement, then maybe you should go every day. So again, it's really sort of getting to know your athlete working with them, but what I always tell people more is not better. So if in fact it has been decided by you and your team that you need a supplement, then probably a little bit lower is going to actually be more productive.

Danny Lennon: Yeah, I think there are some really, really important points there, especially given how we've talked about the importance of iron for athletic performance and obviously when any time an athlete hears that something is good for their performance, the natural inclination is how can I get lots more of this stuff. And I think a few really important considerations you outlined there, first is to make sure this is based off probably some really good quality testing first of all as opposed to just presuming oh I just need lots more iron, so getting some testing to confirm that your actual iron status is low. And then from there maybe one that would be counterintuitive to a lot of people is that just supplementing with super high doses is actually counterproductive. And so, I think that you outlined you are aiming for, if it's going to be dosage and you've confirmed you need it, then somewhere between 40 to 80 mg of elemental iron specifically. And then in terms of looking for a brand, making sure that fits in with any anti-doping guidelines if

you are competing in a sport, obviously that's drug tested as well. So some really, really solid points and I think that are particularly important. Erica, before I get the final question or so, there's one more on this topic that I wanted to ask. and just when it comes to the research we have, where are we in terms of, if we look at athletes who maybe have had low iron status, who then get supplemented to bring that back up, and obviously we know that's going to have a knock-on effect, do we have any research that is in anyway almost quantified what sort of performance improvement some people get in – it will obviously vary from sport to sport, but just how much of a performance improvement could someone get if they are going from iron deficient back to adequate levels?

Erica Goldstein: A couple of points there, the first is I want to mention that whenever I talk about this, I do tend to lead towards talking about endurance sports and that's pretty prevalent in the research but there has been a number of studies that have looked at team sport athletes and anaerobic athletes and we know that iron deficiency is an issue there. There's also been plenty of studies that have looked at females going through basic combat training that are very affected by iron deficiency and these hepcidin cycles and things like that. So I just want to point out to people that I am not just talking about the role of IL-6 and hepcidin in terms of endurance sport but it also affects other types of athletes.

And so, there was one study in particular that looked at volleyball players that is always a good example, and what I liked about this study during my talk about it is twofold. One is that at the beginning of the study all players were trained by a dietician on how to get optimal amounts of iron in their diet, but also how to track what they are eating. So then subjects were divided into a placebo group and then the group that received iron supplementation, and so after – I think it was 11 weeks of training, and these athletes are putting in like a high volume, like 25 hours a week – and what it showed is that people who did not receive the iron supplement, there was a number of athletes that did move into higher deficiency. However, the group that did receive an iron supplement, and that I believe was 105 mg of elemental iron, they saw increases in – I think it was a power-clean and even total mean strength, and that was associated with hemoglobin, which is interesting, because we think about hemoglobin really more related to VO2 max because of oxygen carrying capacity. So that brings up a whole other number of

questions, but I guess, my point is that you may see decreases in strength if you are an anaerobic athlete. And by maintaining your iron levels you are going to see good performance. But also, if you are iron deficient and then probably taking a supplement, you could likely see or you probably will see an increase in your strength and your performance. Also, an endurance athlete, you could be at some event where you are just not placing well and then you get your iron levels back up, you are going to be back in highly competitive condition again.

Danny Lennon: Amazing. That's awesome for people to hear, especially if this ends up being an issue for people down the line. Erica, before I get to the very final question, where can people find more of your work online, get access to some of the stuff we've talked about today or just getting contact with you if this is an area they are particularly interested in?

Erica Goldstein: I am not really great with social media but I do have an Instagram account, it's just ericagoldsteinthomas. So I've been trying to post work there and then I do need to get a website developed or something like that, but I am pretty – a lot of my time is focused on school. But I am really good over email, so they can get in touch with me by email, it's just simply egoldstein@knights.ucf.edu. Any time you want to email me, I will be glad to get back to you. So Instagram or email is the easiest way to get in contact with me.

Danny Lennon: Perfect. I will link up to that in the show notes for all you guys listening if you do want to follow up on any of the stuff we've discussed today. And Erica, that brings us to the final question that I always end the podcast on, and it is simply: if you could advise people to do one thing each day that would have a positive benefit on any area of their life, what would that one thing be?

Erica Goldstein: So for me, it's not going to sound like one thing, but something that has always carried me through or everything I've done is surrounding myself with really good people who can make me laugh, because there's always going to be very serious moments in your day and no matter how busy you are, you have to be around people that are really going to work as a team and no matter what's going on, always find a way to laugh about whatever is going on, because that's just really I think it improves your body and life and your day. And I mean, I can tell you from when I was a dietician, working in a very serious environment, I

mean, sometimes there was just really nothing I could do for some of these patients, but I could always make them smile and make them laugh. And you are just in this very serious environment in a patient's room and all of a sudden you are both laughing and you are sort of transported to a different time and you are able to just elevate things. And I think that's important, so I think choosing to surround yourself with good people and find a sense of humor in things is always going to just make your day better.

Danny Lennon: I love it. A great to finish off, and with that I want to say, thank you so much for taking the time to do this and for the amazing information you've given today, like I said, some really fascinating stuff and I think one that everyone listening will really, really enjoy. So thank you for that and for the continued great work that you are doing.

Erica Goldstein: Yeah, Danny, I can't thank you enough, it's a real highlight of my career to be on your show, so thank you.

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