PaleoSolution-311

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Robb Wolf: Hi folks. Robb Wolf here with another edition of the PaleoSolution podcast. Very excited for today's guest on. Dawn Kernagis is a research scientist in the area of human performance optimization. She does a lot of work with Naval Special Warfare and some DARPA funded research looking at the extreme environments that are our operators exist in as part of their day to day work. Dawn, how are you doing?

Dawn Kernagis: Great. How are you doing today Robb?

Robb Wolf: Really good. It's sunny and warm and nice in Reno so I absolutely can't complain.

Dawn Kernagis: Well it's the same here in Pensacola so --

Robb Wolf: Shocker, yeah, yeah, yeah shocker. Well Dawn give folks a bit of your history and scientific background.

Dawn Kernagis: So actually I got into research kind of from a little bit of a backward path. I started off actually as a professional diver. When I was in high school actually even before I was in high school, I became interested in scuba diving and I was always interested in science. I was always the geek carrying around the big heavy books which is probably I have a bad back to this day.

Robb Wolf: [Laughs]

Dawn Kernagis: But I would carry around big books. I have studied fossils. I studied the oceans. I would read Jack Justo's books from front to back all the time. I just was a total geek growing up. I decided I wanted to learn how to scuba dive. I actually wanted to be a marine biologist. I figured that out at nine because you know where you're going at nine years old. So I learned how to scuba dive and just literally fell in love with it just completely so to speak immerse myself in the sports of scuba diving.

I started working dive shops when I was in high school and I actually started working on cave diving projects when I was in high school as well. So instead of going to prom, I was actually cave diving in the springs of North Florida.

Robb Wolf: [Laughs] Nice.

Dawn Kernagis: I don't have any regrets over that. But yeah so I started working on large scale projects as I gained experience and over the years I got the chance to travel all over the place to Mexico and France and Germany. One of the big projects I worked with over the years from about 1996 to 2007 was a project called the Wood Ville Cars Plane project. It's a deep underwater cave exploration project that's focused around the springs just south of Tallahassee Florida.

So while I was in college, I was driving down on weekend probably a couple of times a month to either dive or also I was a dive manager on the project. So I would oversee all the different team operations, all the people going in and out of the water, upwards of several dozen divers doing pretty extreme dives, stuff that's not in a standard recreational diving format. So you know, dives that were 300 feet in depth typically on average maybe just a little bit less than that for hours bottom time which meant a lot of decompression to minimize risk of getting the benz and a lot of different gas mixes..

You just get thrown into this environment and I loved every bit of it but there's this part of me that you know, over the years while I was doing all this, there's this part of me that wanted to do something bigger and have a bigger impact, both on the diving community but just kind of in general as well.

I started asking some questions. I had some ideas of research that I wanted to go after and my – who turned out to be my advisor in school Dr. Richard Moon I went to him. I wasn't even working at Duke at the time but he's at Duke University I went to him with some ideas and said hey I've got some research ideas, how do we do this, can we do this? He's like yeah I think it's a great idea.

So my idea was to look for potential biomarkers of decompress stress in divers. Up to that point there wasn't anything out there or at least as far as objective biomarkers went. So he's like think it's a great idea but we're going to need money to do that. [Laughs] So I was like well how do we get money. He said well we got to write a grant. He kind of walked me through the process so I ended up writing a proposal to the Office of Naval Research and it got funded.

So then I turned that into my PhD project. I went to ONR and I said well can I do this as my graduate research. They said well we've never funded

anybody as a predoctoral student but I think could be a good candidate. We'll see how this works, no pressure.

Yeah. So we ended up going after it and then I went to Duke and I said hey I've got funding, will you take me as a grad student. They said well yeah of course. I always laugh. If I haven't had funding, I'm not sure if they would have accepted me.

Robb Wolf: Right , right .

Dawn Kernagis: But they welcomed me with open arms. But yeah so it just started off there and then just transitioned into the work that I did as a grad student and then transitioned into work at as a post doc. Now here at the Institute for Human Mission Conniption.

Robb Wolf: Like you were saying, you had to hang out with Dominic D'Augustino occasionally and then Dr. Ken Ford who's one of my favorite people in the world. So I'm incredibly jealous. You go diving all the time. I love spear fishing so I am incredibly jealous.

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Dawn Kernagis: Oh awesome.

Robb Wolf: Yeah.

Dawn Kernagis: Yeah. I haven't had a chance to dive as much since I've been here just because it's that transition period into what's equivalent of a new faculty position. But the opportunities are abound and the gulf coast is absolutely amazing place to go diving. Dom is actually the reason that I met Ken Ford in the first place. So Dom was a post doc while I was a predoc with the Office of Naval Research. He told Ken about me and Ken and I met and it just you know, it transitioned from there.

Robb Wolf: That's fantastic. Dawn tell folks al title bit if they're not familiar with what the challenges are of the hyperbaric environment. Like what happens with kind of respiration and blood gases, nitrogen at normal atmospheric pressure and then what happens as we start getting into these hyperbaric environments?

Dawn Kernagis: yeah it's a great question. So you know, one thing that you're talking about nitrogen so I'm not sure how many of your listeners are divers themselves but there's a condition that you can experience called nitrogen narcosis. Essentially it's breathing higher partial pressures of nitrogen. So as you go deeper specifically when you breathe air, the high

pressure of nitrogen is going to lead to what they call the Martini effect, the Martini's law.

Essentially as you go deeper, the drunker that you feel and the less cognitively focused you are. Your cognition becomes more and more limited and you start to have issues with focusing and task management and it gets worse as you go deeper. So that's one thing.

Robb Wolf: Dawn, what mechanistically causes that? Like is the nitrogen actually displacing oxygen? Is it altering some like glucose receptor sites? Like what exactly is happening in that process?

Dawn Kernagis: that's a great question. So we don't know all the specifics and Dominic D'Agustino has actually done a little bit of research in this area. But they think it has to do with lipid solubility and properties of nitrogen but I don't know all the specifics right now. So what we do right now what the community does is they incorporate helium into the breathing mix. So helium has a much lower narcotic effect than essentially a nil narcotic effect compared to nitrogen. So the divers are able to perform with better task loading and have a better cognitive performance with helium replacing that nitrogen in the gas mix.

Robb Wolf: Got you. Got you.

Dawn Kernagis: Yeah. And so then you have oxygen toxicity which can take the form- so what's interesting is we think oxygen is a great thing but too much oxygen is actually a bad thing. So you can have two different types of oxygen toxicity. One is pulmonary oxygen toxicity and it tends to be when you breathe higher pressures of oxygen for longer periods of time. I was talking about the divers that we worked with and the case system in Florida. Those divers would breathe large amounts of oxygen during their decompression. Both during the dive but also during decompression. So as they're coming up from their dive, they're breathing higher and higher partial pressure of oxygen as they come up slowly but surely and that helps to get rid of that inert gasses in the blood and tissues and kind of creates that pressure differential.

The problem is that the lungs actually get kind of beat up from that and they think it has to do with oxidative stress, inflammation. So get kind of like a cough and kind of raspy breathing and you have reduced pulmonary capacity. So that's pulmonary oxygen toxicity. Now then there's also central nervous system oxygen toxicity and this is a lot of work that Dom's been doing with the ketogenic diet and ketone and ester administration has been looking at CNS oxygen toxicity.

This is where divers when they breathe extremely high or partial pressures of oxygen so if you breathe 100 oxygen at two atmospheres so essentially at 30 feet or even deeper, you have this increased risk of developing seizures underwater. So they're grand mal style seizures and obviously that is not ideal underwater. There's a higher risk of drowning with that.

So those are two major considerations. So you would say well okay you can minimize the risk of something like nitrogen narcosis and then also decompression sickness which I'll talk about in a second by just eliminating all the inert gas or just trying to minimize the amount of inert gas and your breathings gas. The problem with that is then you increase your risk for oxygen toxicity which can be very deadly.

Robb Wolf: So this is some of the imagine there's a – I'm not a I've never done much scuba diving. I mainly do free diving so this stuff is pretty new to me. But I would assume there is kind of some charts and rubrics like if you're going to be at this depth for this duration then we would probably recommend this air mixture so that we're minimizing oxygen toxicity versus nitrogen narcosis and whatnot. I assume that stuff is fairly well fleshed out?

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Dawn Kernagis: Yes. So for the recreational diver, for the standard person who is getting certified to scuba dive, typically there are three types of gasses that they breathe. So either air, which is pretty straightforward you know, just compressed and they have two different types of what they call nitrox. Essentially it's like air but it has an increased percentage of oxygen so either 32% or 36% oxygen in the gas mix and the rest is nitrogen. It just helps minimize that inert gas uptake that nitrogen uptake so it makes the dive safer with respect to the risk of decompression sickness. So but then you also have depth limits with those gasses because you do have a higher partial pressure of oxygen in them. So you don't want to have that risk of CNS oxygen toxicity.

SO with respect to some of the more advanced diving, so either the technical diving, the deep diving or even military diving, they have different gas mixes that they use that's highly dependent on the mission, the depth, the duration. So different levels of helium in the mix, different levels of oxygen in the mix. So yes it's flushed out but there's still a lot of back and forth with respect to what the optimal mixes are for a lot of these different missions.

Robb Wolf: Right. And then you have further wrinkle in this whole story with rebreathes right?

Dawn Kernagis: Uh-hum.

Robb Wolf: Yeah. Could you talk a little bit about that?

Dawn Kernagis: Yes. So rebreather technology is essentially it's incredible. So for a recreational driver it's great. So just going back, a rebreather essentially scrubs out the carbon dioxide that you exhale and it helps kind of recycle the gas that you're breathing which is great. it's a closed loop system. It helps save the gas supply that you have. So essentially your gas supply that you have typically will last you longer because you are kind of recycling the gas that you're breathing. But there are risks involved with that as well because it is a closed system. It is a little more complicated than a typical just basic open circuit what we call open circuits systems, so this is basic scuba set up.

Yeah and then military tends to use these rebreathes a lot. The technical diving community uses them a lot that's because just for safety factors for building in that redundancy and that extended gas supply.

Robb Wolf: Uh-hum. And part of that is because even though with each breath hat we take we remove a certain percentage of the oxygen out of that breath but then when we exhale unless we just like hold our breath for two minutes or something we still have a significant amount of oxygen that's still left. We're putting out a decent amount of oxygen but also some carbon dioxide and then these rebreathes pull the carbon dioxide out of that mix.

Dawn Kernagis: Yup. Exactly, exactly.

Robb Wolf: Fantastic. So where are you looking at for – I noticed in some of your graduate work, that you are actually looking at some genetic considerations of tendency towards developing the benz, the nitrogen problems with coming up from depth too rapidly I've talked with Dr. Kirk Parsely who's a former Seal, now he's a physician and he's one of these people that he literally has never been sick. He cannot get a hangover and he appeared to be immune from the benz. Like he just never had any symptoms with it. Did some rather knuckle headed go down deep come back fast no problem. So are there some genetic differences there and if there are what's kind of driving those differences?

Dawn Kernagis: Yes. that's a great question. So actually funny enough so another round of connections that you and I have. So I actually met Dr. Parsely way back in the day before I ever started graduate school. We met at an undersea

medicine conference in Hawaii through mutual friends. Actually we were talking about getting here to IHMC to talk about his sleep research.

His name came back up in another conversation with Peter Atiya actually and yeah so I laughed because it's a very small community when it comes to human performance optimization.

Robb Wolf: right.

Dawn Kernagis: But Kirk is a great guy and he's doing some incredible work. So yeah it's cool to hear his name. but yeah so as far as you know, predisposition or immunity if you want to call it that to decompression sickness that's a great question. So the work that I did kind of starting off while I was looking at genes and how they're expressed in response to decompression stress. So I actually didn't cover decompression stress and the different risks but essentially decompression stress you know you have this inert gas uptake in your blood and tissues as you descend and as you dive while you're doing the bottom phase of your diving as you come back up.

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If you reach a point where the partial pressure of the gas is in the blood and tissue that inert gas is larger than the surrounding pressure. You can have bubble formation and bubble formation could potentially lead to the development of what we call decompression sickness. So it's a heterogeneous syndrome where anywhere from "pain" only which I think if you're the person receiving that pain you're not thinking it's pain only but all the way up to CNS decompression sickness, pulmonary decompression sickness and pretty severe forms of decompression sickness.

So what's interesting about it is so you think oh well if you just measure all the bubbles and then count the bubbles and when you're doing these dives. So there are different ways that we can measure bubbles in the blood and tissue. So one is listening for them through using Doppler ultrasound. The other way is using transthoracic echocardiogram. So essentially you're looking at bubbles that are passing through the vasculature. You can actually see like in some dives with people there's so many bubbles. When you're looking at the heart as the bubbles pass through it's actually wiping out the image of the heart wall. There are so many bubbles.

Robb Wolf: Wow, wow.

Dawn Kernagis: So what's interesting about this is I had the chance to do field studies and all my graduate student cohorts would laugh at me. They're like you have such a tough job you have to go to Gran Caymans to go study deep divers.

Robb Wolf: [Laughs]

Dawn Kernagis: But we would follow these guys and girls who were doing pretty extreme diving exposures just like the ones that I talked about in the projects that I had worked with earlier. And they're doing it by choice. You know, so it wasn't anything that an IRB would ever let you get away with in a research setting. But for us we were able to just kind of watch and observe these divers and do the transthoracic echo to see how many bubbles they're coming up with. What was interesting is there are some individuals that didn't bubble a lot typically kind of on a regular basis but there are some individuals who bubbled a ton every day and they never showed symptoms.

Robb Wolf: Hmm.

Dawn Kernagis: They weren't lethargic at least not that they told us right. So I think we had one hit over the course – we have one case of decompression sickness over the course of several years of me going down there which is pretty impressive considering we have followed about a dozen plus divers every here and these are divers a lot of them are bubbling severely on a daily basis and just no symptoms.

So it's really interesting. There's a discrepancy between detectible bubbles so and I will emphasizes that because maybe there are bubbles out there that we're just not seeing and those could be causing symptoms somewhere. So but there's a discrepancy between detectible bubbles and actual development decompression sickness.

Going back to my graduate work I said well what if we look for an objective biomarker? There's no objective biomarker of like the pathophysiological stress that's being incurred by the body in response to these bubbles being around. So at first I had this list of like 40 something markers I wanted to look at based off of compliment activation and coagulation and inflammation and the I took a step back and I was talking with one of the professors at Duke and he said there's this new technology called Gene Expression Micro Array Technology. Essentially from a single sample, you can look at thousands or tens of thousands of transcripts. Essentially, the signal from a gene that's being expressed.

You have DNA to RNA to protein so essentially you're looking at the RNA message that's coming from that gene. So the genes that are being turned on or off in response to a certain stress and you're able to kind of look at these changes between provide versus post dive. So what I proposed was to look at gene expression micro array, use that technology and blood sample that were collected before a dive. So it's just getting an individual's baseline before they go in for a dive and then after a dive. I would have loved to have gotten a timeline of these changes in gene expression but you know, funding is relatively limited so we had to be smart about it. So we picked the two hour post dive time point because that's typically just after when you would see peak bubble formation.

So we did pre versus post and we looked at over 14,000 transcripts so over about 14,000 genes that we were able to measure simultaneously from a single sample and compared those genes pre verses post dive in each individual. And what was interesting is it was peripheral blood samples so I mean a lot of the things that we found that were activated were things that you kind of would expect given that you're looking at peripheral blood cells. So we found immune response, we found oxidative stress response. We found compliment activation related genes but there seemed to be this kind of consistent signature that was related to what we termed as decompression stress.

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So the idea from there is to go forward in future studies and say okay these are some of the key genes that seem to be activated in response or even down regulated in response to decompression stress. Is there a difference in the individuals with respect to how those genes are regulated and are those genes related to predisposition to decompression sickness or even as you said resiliency decompression sickness.

So it's kind of a starting point that we had at least to kind of get some of the gene candidates that we want to look at down the line. What's also interesting is there are studies that were done in other settings looking at peripheral blood mononuclear cells and that settings that are kind of similar to decompression stress. So what we would think of as what's causing decompression stress. And that includes cardio pulmonary bypass and so what's interesting is a lot of the genes that they found and some of these studies were actually conducted at Duke University before I started my studies. Some of the genes that were found to correlate with a person's increased risk of a poor outcome after cardio pulmonary bypass were actually some of the same genes that we found in our studies as far as those that were activated kind of significantly in certain individuals after diving.

Robb Wolf: Interesting. Is there any similarity between that decompression process the inflammation and whatnot and ischemic reperfusion injuries?

Dawn Kernagis: Yes. that's a great question yeah.

Robb Wolf: Okay.

Dawn Kernagis: Absolutely, especially depending on you know, if you have a bubble that gets trapped essentially in a vessel and then it's released you do have this ischemia reperfusion injury.

Robb Wolf: Okay. okay.

Dawn Kernagis: Yeah it's a great question. Yeah.

Robb Wolf: So you could have like maybe even independent of the ischemia from drops of large bubble you've got some oxidative stress and some general damage and then you actually do potentially get the ischemic reperfusion injury which is a big deal in my tissue transplant and stuff like that yeah.

Dawn Kernagis: Yeah.

Robb Wolf: Interesting.

Dawn Kernagis: Absolutely yeah. It's really interesting going through the literature and even things like when I was in grad school one of my good friends does research in the area of radiation injury, radiation induced injury. A lot of the same genes and a lot of the same pathways that we were seeing in our studies were popping up in their studies. So this oxidative stress response, this inflammation it's all the things that you would think of so there just seems to be this overlapping theme of you know, kind of oxidative stress trying to minimize inflammation and so.

Robb Wolf: Right. And it's interesting to me that like the ketogenic diet is being studied both for hyperbaric oxygen stress as well as hypobaric like both a high altitude and you know, arguably multiple atmospheres of pressure and very different environments but both of those creating some substrate utilization challenges and then also oxidative stress and the ketones, ketone esters might be a really powerful tool for all of that.

Dawn Kernagis: Yeah, absolutely and going back to what I just talked about with the radiation same thing. There looking at it for protection against radiation induced injury both in the brain and also globally. Yeah. So it's kind of

these underlying pathways that your body has in place to essentially kind of protect us against injury but it seems to be kind of this consistent theme of oxidative stress and inflammation kind of global inflammation that we're trying to reduce so.

Robb Wolf: Interesting. Interesting.

Dawn Kernagis: yeah.

Robb Wolf: Before we started recording, you said that your specific area of research isn't as much in the ketogenic diet realm but how much are you fiddling that with the folks that you're working with. I'm still trying to figure out what are the good general population recommendations are around the ketogenic diet. Like I tend to work with a lot of in the May athletes and these really glycolytically based athletes. I've had a heck of a time making a more ketogenic type diet work in those folks like using some MCT oil has helped because we can still keep some carbs in the mix and what not. But do you have any thoughts on kind of general population application with some of the research that you're doing and also potentially the ketogenic diet for folks?

Dawn Kernagis: Yeah. I mean that's a great question as well. So for the research that we're doing, a lot of the applications we're looking, you know, this goes back to my area of research specifically is operators in extreme environments. So like you were talking about, people who are going to hypobaric environments or hypoxic environments like high altitude operators, high altitude aviators, we're looking at it with respect to the diving population. So Dom's work with CNS toxicity in Navy divers, we're looking at it or at least I say we it's more Dom that's doing this work not me.

Robb Wolf: Right.

Dawn Kernagis: But we have this arms. So what's interesting is so much research is more focused on the molecular level changes that are occurring and so we have in a lot of these studies that we're proposing, we're proposing to include a ketogenic diet or a ketone ester supplement arm to the studies to look are these individuals further protected in these extreme environments. Again it's because you have this kind of same theme that's going on of oxidative stress environment essentially.

The other interesting one is the astronaut population. Again Scot Kelly actually just back to earth.

Robb Wolf: Right.

Dawn Kernagis: So yeah that's another really interesting one because of there are a number of different factors that they're facing including potential radiation induced CNS injury and just kind of a global oxidative stress environment that's another population that we're looking at. As far as the general population one of the things that we've talked about looking at is looking at genetic factors related to ketogenic diet response. So are some people just genetically do they respond better because of some kind of basis of genetics to a ketogenic diet or ketone ester supplementation compared to others. That's the area that we're getting ready to get into or we've talked about at least with the general population so. I don't want to speak for Dom because that is his area of research but yeah I think that there's a lot of interesting questions to be answered.

Honestly if you're talking about global inflammation,, you're talking about all of us on a daily basis.

Robb Wolf: right.

Dawn Kernagis: Just based off of the stresses that we put ourselves through some of the basic just psychological stress, diet, just general exercise exposure to just kind of the daily living essentially. So I think that there's definitely a lot of applications there and one big questions is how are people responding and how can you optimize that within the general population. Yeah,.

Robb Wolf: Right. This is possibly totally out in the left field but did you see any significant GI problems from folks that were maybe more prone to decompression problems? I'm fishing and asking somewhat of a leading question but did you have any sense that these folks had an increased levels of like GI distress or irritable bowel syndrome or anything like that?

Dawn Kernagis: Not that I know of but that's a really interesting question. I'm kind of curious are you getting to like gut microbiome, is that where you're leading with that or…?

Robb Wolf: I'm wondering just gut microbiome and potentially also just you know, like if we see changes in the intestinal permeability you know, like LPS trans locating into the circulation just with a missed night of sleep or with a really vigorous exercise and stuff like that. So I'm just wondering if this would fall within that spectrum of being kind of potential GI irritant and yet again maybe some sort of a ketone intervention or like an anti-inflammatory diet intervention could helpful with that. I've worked with

the naval special warfare for about six years and it was interesting when I first started kind of peppering in this paleo diet like the guys that had already been playing with it and they reported a lot of different benefits, they just seemed to bounce back from training more effectively and particularly guys that were getting up there a little bit older which older and Seal population is like post 30 you know?

Dawn Kernagis: Right.

Robb Wolf: I mean these guys take a lot of abuse but it was interesting to me and a lot of them reported that they saw improved digestion. Like they had gas and bloating and maybe some GERD and whatnot previously and then they would eat kind of a paleo anti-inflammatory diet not even necessarily ketogenic and they would report some improvements. I'm just wondering if that's potentially another angle that could be investigated trying to have as little of an immunogenic load or a gut irritating load. Like if the gut is already kind of under assault is that another factor that could exacerbate the overall system and it's complete gas, I know nothing about any of these but just throwing it against the wall.

Dawn Kernagis: No. I think it's a really interesting question and yeah we'll have to put in a proposal and get you involved in that so.

Robb Wolf: I'll help write the grant that sound super interesting. Some people are well known for abs, I'm known for poop so that's my areas of expertise is poop so that's interring. Have you played around at all yourself with a ketogenic diet as part of your diving?

Dawn Kernagis: I have not. So what's interesting. So I have friends who are very interested in it and I pointed them in the direction of talking to Dom actually especially some of the divers that are still involved in those projects that I talked about. but I have since retired from some of the deep divers who are undergoing extreme loads with respect to inert gas but also exposure to high partial pressures of oxygen.

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So one of the big concerns that they all have is how do I reduce my inflammation, how do I kind of protect myself against the assault from these dives. So a lot of them have been turning towards ketogenic diet. I have not been doing that kind of diving in the last –since I started grad school essentially. It's one of those things that unless you're doing it all the time it's not a very safe thing to do.

Robb Wolf: Right.

Dawn Kernagis: But if I were doing that kind of diving again I would definitely start dabbling in that direction more. I played around it a little bit. I mean obviously being here at IHMC and with Ken Ford, we get exposed to all kinds of amazing ketogenic food. So you know, we are spoiled rotten and even Ken's ketogenic ice cream and IHMC ketogenic ice cream and also Dom. You know, Dom and I kind of do this tag team presentation. We have worked in a couple of different groups where he and I both present so we end up going to a lot of the same meetings. So I play around with it just spending more time around these guys. But if I were really putting myself out there doing those kind of dives I would definitely be looking in that direction so.

Robb Wolf: Interesting, yeah.

Dawn Kernagis: Yeah.

Robb Wolf: I continue to fiddle with it like I eat on the lower carb side of things. I use some MCT oils. I unfortunately fell in love with Brazilian jujitsu which is a very glycolytic based sport and I've really tried to crack that nut. Ken has just leaned on mercilessly. He's like you've got to stick with it. I've done it for six, seven months and just kind of missing this low gear. I already get the tar beat out of me at jujitsu and so I dropping another 10% or 15% off my performance is just what my ego can handle But I keep fiddling at that lower end of this. I definitely seem to do better. I just did some genetic testing through 23andme

Dawn Kernagis: Okay good.

Robb Wolf: Both of my parents developed type 2 diabetes early in life, poor diets, alcohol that sort of stuff. But it was interesting that according to the 23andme findings, I'm about 300% more likely to develop type 2 diabetes than the standard population. I definitely am the doe northern European guy if my carbohydrate intake starts creeping up too much. So there's something to that for me so I continue to fiddle around with all that.

Dawn Kernagis: Yeah. I've got the same genetic makeup as kind of those combination Norwegian-Lithuanian so I had in that direction. But lower carb and I just kind of – I mean I know ketogenic diet is not lower carb so that's not the basis of it. But just trying to pay more attention to my food intake. I will say that being here at IHMC is definitely transitioned that kind of mindset significantly compared to when I was at Duke so.

Robb Wolf: Yeah man.

Dawn Kernagis: Yeah.

Robb Wolf: It's nowhere to hide there yeah.

Dawn Kernagis: Yeah.

Robb Wolf: Yeah that's awesome.

Dawn Kernagis: Yeah.

Robb Wolf: Dawn, what's your next area of exploration that you're working on?

Dawn Kernagis: Yeah. So we have a couple of different co-projects some that are out as far as proposals go and some that have been approved and are moving forward. So one thing that we're doing is actually this just got funded is a knowledge based model of undersea medicine. So at IHMC they've developed this tool called concept mapping. Actually some of the world's leading experts in concept mapping are here at IHMC and actually are founders of IHMC. So essentially it's just kind of organizing the knowledge for the undersea medicine county and kind of putting it in a format that's tangible on the user end of things. So either that's a program manager from Loft's Naval Research or it could be a diver themselves or it could be someone who wants to get into research and say what kind of research has been done up to this point and how does everything connect.

So that's one project that we just got funded from ONR and we're really excited about moving forward with that. Some other studies that we have that are out there right now that have been proposed, and several of them are slowly but surely moving forward, is looking at epigenetics so looking at changes to how our genes are expressed and potentially permanent changes or even inheritable changes in response to different diving exposures or even extreme environmental exposures.

So it has not been looked at in our area yet I our field but I can only imagine with the stresses that we experienced and the oxidative stress and the inflammation and everything that we've been talking about that you are going to some types of epigenetic changes that occur in these populations. So in extreme diving populations we're looking at potentially saturation diverse. We're potentially looking at the submarine population. So you know, all this is just highly dependent on whether or not the funding kicks in. But that's kind of the next area.

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And then another area of interest that we're putting forth is looking at the lymphatic system. So looking at the brain lymphatic system and how that's affected with extreme environmental exposures. So we've got a couple of questions there with respect to both diving and immersion and also space and microgravity. So we're going to kind of push all of that forward.

Robb Wolf: Oh fascinating stuff. Wow that's amazing.

Dawn Kernagis: Yeah.

Robb Wolf: Amazing.

Dawn Kernagis: Yeah.

Robb Wolf: Dawn, where can folks track you down on the interwebs or find out more about your work?

Dawn Kernagis: Yeah. You can find my page on IHMCs website so just Google Dawn Kernagis IHMC and there's a link to my site and actually contact information is there as well. So if anybody has any questions or thoughts or ideas please feel free to reach out to me.

Robb Wolf: Fantastic and we'll have a link to that in the show notes. Dawn it was really fun having you on the show. Theoretically I'm going to be out your direction in October I think.

Dawn Kernagis: Awesome.

Robb Wolf: October of this year, I think so. I Ken invited me out there. Clearly the standards at IHMC have plummeted dramatically if they're going to have me go out there and do a talk so I'll --

Dawn Kernagis: No, no, no.

Robb Wolf: I'll do my best to represent. I started looking at some of the list of presenters and I'm like oh my god I am terrified to go get in that scene but I'll do the best job I can.

Dawn Kernagis: No, we're excited to have you out here and you'll be treated to the best ketogenic food I can promise you that so.

Robb Wolf: Fantastic I love it. I love it.

Dawn Kernagis: Yeah.

Robb Wolf: Well Dawn thank you again so much for coming on the show and I look forward to meeting all of you guys in person here soon.

Dawn Kernagis: You too. Thank you so much Robb. I appreciate it.

Robb Wolf: Okay. talk to you soon.

Dawn Kernagis: Take care.

Robb Wolf: Bye-bye.

[0:37:13] End of Audio