Danny Lennon: James thank you so much for taking the time out to do this. I appreciate you coming on the show my man.

Jamie Pugh: No, thank you very much, it's a bit of an honor to be on air; listening to the podcast for a couple of years and you are going to go look at the list of names of people you got on, I almost feel a bit of a fraud being early in my research compared to some of those guys, so thanks for having me.

Danny Lennon: My pleasure. I am interested to hear more about some of the work that you've been able to share with me that you've published along with some of the other people within the lab over there. So maybe to start off before we get into any of that stuff, just for people listening, give them an introduction to who you are, the research that you've been doing, where you are located and all of that type of stuff.

Jamie Pugh: Yeah, no problem. I've spent the last probably three and a half years at Liverpool John Moores just doing my PhD there under the supervision of Graham Close and the team there, and what we've been doing is we've been looking at gastrointestinal symptoms and function and damage during exercise, predominantly endurance exercise and then off the back of that we've been looking to see if supplements – so the two we really concentrated on glutamine and more so probiotics, what effects they can have for athletes, so as I said, in terms of either reducing damage, reducing permeability, and ultimately reducing symptoms as well.

Danny Lennon: Brilliant. So we are really going to try and dig in deep into some of that throughout the course of this conversation hopefully. So maybe for a starting point when we are talking about this idea of gastrointestinal symptoms or GI distress within athletes, what is the type of range or symptoms that could be experienced, what are some of the typical things that we classify as a symptom?

Jamie Pugh: Yeah, so this is one of the really interesting starting points that we sort of had when we started the PhD was, it wasn't necessary to be defining the terms, lots of them are already defined, but it's just looking at the range of symptoms you could have and then what's maybe been difficult in research that's already been published is then trying to look at causative factors but if you think you could have anything from heartburn, acid reflux, nausea, upper abdominal and lower abdominal bloating, constipation, diarrhea, urgent need just to go to the toilet, and so you look at widespread there, and so when you are trying to, you just ask really widespread generic questions that some studies have, and then you try and define maybe one or two causative factors then that's why it's been quite difficult. So our starting point was just to try and see how prevalent were some of these individual factors and then we came up with it as well, we also wanted to see what was the prevalence like, not just in endurance athletes, which is where most of the research has been done, but just in elite sport, so across a range of sports we tried to look at to begin with.

Danny Lennon: Sure, and I think seems that this has been an area that has been looked at predominantly in endurance sports like you mentioned so it's cool that you guys have started to try and explore other elite level athletes outside of that and we will definitely get onto both of those separately. So from a starting point of we have these set of symptoms that you've tried to not only define but list out some of them that you just mentioned, how did you go about scoring those or determining how severe or mild a certain symptom maybe or if it's present or not in some of the studies that you've done?

Jamie Pugh: Yeah, so I think that's really important, because some of the early studies, they show really high prevalence rates, so especially in some of the say marathon runners or endurance runners, you've got some studies that report maybe 90% of athletes suffering from symptoms. But when you get into the paper, you just see that those symptoms had no defined criteria or no defined

severity of symptoms. You could have someone who's just got a little bit of gas and that's being classified as a symptom, and ultimately it's not going to affect performance. So we've tried to not only look at how prevalent it is but how severe it is as well. We've used a couple of different tools depending on the study so some of the ones where we've maybe not have the chance to get hands on with athletes and it's been a bit more remote, we've used a validated questionnaire that's been used in large online studies before, so that's look at a 1 to 7 scale with definitions of each of the symptoms in layman's terms, just so the athletes can sort of without further explanation understand and go through it. And then when we've had ones in the lab, we might use a slightly different scale so we do have the chance then to go through it with people, and we generally usually look at scale, so 0 no discomfort all the way through to maybe a 10 which is severe discomfort, maybe need to stop exercising.

Danny Lennon: Right. And so when we are talking about these symptoms that can arise within athletes particularly during exercise, what are some of the – there's kind of maybe primary classes of causes for some of these symptoms, and obviously that will probably depend on the symptom itself but are there different causes that may lead to some of these symptoms, and if so how should we think about those?

Jamie Pugh: Yeah, definitely. So the traditional one that sort of everyone hears around is of obviously that during exercising, blood is going to be shunted away from the digestive tract to the working muscles, so as soon as you get that shunting of blood away from that you get a slight reduction in function so you can get slow gastric emptying and you get reduced absorption from the intestinal tract. So that can then even potentially lead onto cell damage, increased permeability and that's where you can maybe get translocation of bacteria toxins across the intestinal cell line. So even from that there are a number of potential mechanisms by which you can get the symptoms. So if you've got a reduction in say gastric emptying that's obviously then could potentially be what leads to initial nausea or burping or upper abdominal bloating.

As soon as you go further down the intestinal tract, then if you have the late absorption, that can have both upstream and downstream effects either speeding up one end or slowing down the other end. So this is where we sort of come to and then it's difficult to put your finger on one potential cause, and it's what

we've certainly seen in the five or six studies that we've done. So we tried to throughout the PhD, we looked at some of the systemic markers of gastrointestinal damage and in a number of studies we've looked to see do these correlate or these associate it with the number of symptoms so do they associate with nausea, bloating, urge to go to the toilet, and we found that they don't. And we've gone from one hour of running, all the way through to – we haven't published the data yet but we did last year a marathon on an athletics track so that's exercise, so some of those guys five hours in duration, and even in those some of these markers they just didn't seem to be associated with symptoms of any sort.

Danny Lennon: And that's really interesting and, like you say, it just makes it so much more complex, we are trying to pull some of this apart and really borrow down to what some of the root causes maybe.

Jamie Pugh: Even in some of the studies that have shown associations with either endotoxemia or permeability, they are in some of the ultra endurance events, some of the 100k plus runs or something like that. But at the same time all of those studies about duration, of exercise have shown no effects. So it's not to say that it isn't or it can't be a cause, but it's just that it does seem to be this differentiation between people where even if somebody is experiencing the same level of endotoxemia or permeability or whatever that marker is, you can still have that one person with symptoms and one person without, and that's something that we are trying to look into a little bit more.

Danny Lennon: So I think that's a really important distinction that you touched on. So if I am picking up correctly you are essentially saying for something like whether it's a marathon or other similar event that you've looked at where we have either this physiological damage due to that reduced blood flow to the gut or just the mechanical effect of them actually bouncing while they are running or whatever it is that's causing some damage. You can pick up on some of this damage to the gut lining or you can pick up on these markers of endotoxemia amongst most or nearly all people but they are in terms of who experiences symptoms it can be widely variable even if they have the same underlying markers. Is that correct?

Jamie Pugh: Yeah, definitely. So it was interesting when we teased the part, some of the – like I said, the marathon day particularly, because

that's the one where we probably have the largest range and some of the highest values. The two people who have the highest marker for some of these, so we looked at intestinal fatty acid binding protein and lactulose-rhamnose is sort of an indirect marker of permeability, two of our runners who were two of the quickest, had two of the highest concentrations of markers for some of these, actually had the lowest symptoms. So they've run relatively harder, so as a percentage of what we would estimate it to be there, the VO2 max, so the personal best, they run the quickest of run, close to two hours. They've systemically shown quite high levels of gastrointestinal damage yet often finish the race with zero symptoms.

Danny Lennon: That's so interesting. Has there been any kind of leading hypothesis that you guys have promoted as to why we might see this variation that some people just seem to be more susceptible to these symptoms than others?

Jamie Pugh: I think there's a number of possibilities. So one of them is that – and this is something that's been postulated by the Monarch group who've done quite a lot of research over in Australia, so it's a hypothesis where they've said that potentially it could be differences in the microbiome. So if you have some levels of dysbiosis, then there's the extra potential for gram negative or positive bacteria that can cross the intestinal lining when you do have this increased permeability; so essentially even if you have two athletes who have increased permeability, increased damage, what is then going across into circulation could be different and that could be the reason for some of this.

Danny Lennon: Sure. So I do want to back up just for one moment just so we have everyone on the same page. We've talked about two things there that can be looked at as potential markers for damage, so you've discussed gut permeability and also endotoxemia, so maybe just so everyone is on the same page, how should we define or think of what permeability is and why is it a problem if that does actually increase?

Jamie Pugh: Yeah. So permeability essentially refers to – so if you imagine your intestinal cell line and the cellular level is composed of the cells that are almost knitted together, so you have these tight junction proteins that hold them together at the apical border and then when you get this exercise induced reduction in blood flow, plus the potential for maybe heat, these proteins that hold them

together can become dysregulated and the pulls between the cells can increase in size. So whereas they would normally stop molecules or compounds of a particular size, being able to pass through between the cells, then obviously if there's no transport for them within the cell, they can't cross the border. If the gut between these cells was big enough, then you can have things then such as bacteria or peptides that aren't completely digested, there's potential then that they can cross through.

Danny Lennon: And so this endotoxemia, where does that come in and what should people think of when they hear this term?

Jamie Pugh: Yeah, endotoxemia is interesting one so it's typically measured looking at lipopolysaccharides so LPS, it's not something that we directly measured, I think there are a few issues with some of the assays or some of the sensitivity, but the reason behind that is if you get this crossing of bacteria or bacterial compounds across the intestinal cell line and this can then be the start of the trigger if you like for an inflammatory cascade. So you got a big release of inflammatory cytokines and again just one of the issues of working the intestinal system that we've had is that, as I said, if we already know there's potential for difficulties like in LPS and on the flip side if we just look at the end product. So we could just look at levels of inflammatory cytokines, but we obviously know the exercise itself being from the work in muscle, there are going to be cytokines produced from that. So it's impossible to then determine where or what's the source of the cytokines. So when we looked at the relationship between interleukin 6 or some of the other inflammatory cytokines, we haven't necessarily seen a relationship there either with some of these and GI symptoms.

Danny Lennon: So one thing I did want to ask about was that earlier you mentioned that we can get some of these symptoms that arise due to something physiological like this reduced blood flow to the gut, I think we just mentioned there just the fact of exercising can cause some damage there as well mechanically and then there's also the one that maybe a lot of endurance athletes listing we will know about just the nutritional component of taking in certain supplements whether that's gels or liquids or whatever during exercise or during an event, so typically with some carbohydrate powder you see quite often people say that if they take maybe too much then they start to feel some of these symptoms. Now there's probably typically we could just think of this as well we have to find out how much you can tolerate and don't take too

much at one go but one thing that you just mentioned earlier Jamie was that we may have people who have this difference in their gastric emptying and therefore they can maybe not be able to deal the same amount of say glucose as someone else at the same time, and that might make them more susceptible. So this kind of changes some of the narrative of just thinking about, well, what is a dose that all athletes should use versus, well, maybe your overall gut health is now determining how much you can handle it. Is that somewhere a fair statement?

Jamie Pugh: Yeah, definitely, particularly I think this is the case with maybe some of the recreational athletes. So we've had athletes in where we've given them about 1.5 gm per minute, so I suppose about 90 gm an hour of just glucose for a couple of hours, in some instances up to three hours, and we get zero symptoms when they are cycling, which is a bit counterintuitive to what some of the other literature would maybe suggest when you think of the, we think there this cap on, glucose oxidation and absorption of around 60 gm per hour. So even that is, I think that would maybe surprise a lot of people because like you said, there's this – we often think that if you take on too much, you are instantly going to get symptoms, but what we've seen is maybe the, like I said, the exercise is – maybe there is something in the cycling but also in the duration as well, so if you just think of the timing of how that's got to go through the stomach into the small intestine you are probably, it's not going to give you symptoms until it maybe reaches the distal portion of the small intestine where you might start to get malabsorption and start to be fermented by the bacteria, you might start having a knock-on effect and slowing gastric emptying down where you maybe get – and you start to get nausea, you feel the need to vomit.

So I think that's the one side, but definitely on the other side if you do take on too much and we've seen again big variations in how much some of these athletes can oxidize in an hour, but there are studies also again that have shown it’s trainable, and so there's some really good work by [Asker] Jeukendrup. Again, the group in Monash last year did a really nice study where they showed just two weeks of what they termed gut training can greatly reduce gastrointestinal symptoms when you are taking on a high carbohydrate load and they used a hydrogen breath test to look at the carbohydrate malabsorption and showed that it was this reduction in malabsorption that they then suspected was the reason for this reduction in symptoms.

So as much as there probably is an individual variation, it's not to say that it can't be trained. And I think that's something that we maybe start to hypothesize one of the reasons particularly as I said in recreational athletes that you do get these, in some instances, severe symptoms because what they will often do is maybe occasionally take a sip of water or a sip of something when they are out in their training runs for three-four months, but then as soon as they come to competition and there's water out on the road or there's carbohydrate gels or there's drinks, they will start to put things in that they've never taken on before and it's maybe just this back to the not used to consuming this amount of fluid or carbohydrate during exercise that will then give them symptoms. And like I said, there are a number of others have shown that if you do this in elite athletes they can greatly reduce the number of symptoms they get.

Danny Lennon: Yeah, that was what I was going to ask about when it comes to some recreational athletes is you typically see exactly that scenario you just laid out of suddenly they have this, they've signed up for a marathon or something else and the event rolls around and then suddenly their nutrition and supplementation strategy becomes wildly different or you see people even in other sports I guess do this and maybe part of that is down to just the conventional thought around carb loading or they've seen elite athletes do it and they start to pay a bit of attention the week coming up to their event, but they've never eaten or supplemented that way before. I know I've certainly seen it even in combat sport athletes, for some reason once they weigh in, they start eating things that they haven't eaten for month.

Jamie Pugh: Yeah, never eaten before, yeah.

Danny Lennon: It's kind of crazy.

Jamie Pugh: Yeah, so we published a study couple of months ago where we just looked at the food intake in recreational marathon runners, so we looked at it 24 hours before the race, the morning of the race and then during the race, and our hypothesis in the lead up to it was that we would see some sort of association between a macronutrient or total calorie intake, total fluid intake with at least one GI symptom during the race itself. So we had about 100 recreational athletes take part in this and we found no association whatsoever. And so that was a bit of a surprise to us because

some of the, again, variations in total calorie intake, fluid intake, fat intake, some of these, and even during the race, like I said we had from obviously 0 gm all the way through to, I think we had the highest at about 95 gm of carbs per hour but there was no relationship that we could tease out. I think it was maybe because of this reason, this is what I am thinking is why we didn't see that, maybe it was just in differences in how much some of these guys had practiced what they would do in beforehand. Like I said, it's one of those that come at the end of it, it's something basically I just wish we adapt to people, you know, did you practice this pre-race nutrition are did you practice that in race nutrition, because that's kind of one of the reasons. But on the flip side, another thing I think it could be is that not to do with the service to any recreational runners but I think if they are running a relative intensity that's slightly lower, so obviously they can in absolute speed they are going to be running slower. But if relatively they are running an easier relative pace as well, then perhaps you can then be afforded a little bit more leeway in what you can consume. So I think that might be part of this as well.

Danny Lennon: I think from a practical perspective another question that a lot of these athletes tend to ask is when it does come to supplementing during an event, and they are obviously going to be trying to prioritize carbohydrates, is there any kind of preference for what type of supplementation you go for, should they use a mix of things, so people might ask about like a glucose supplement versus something like waxy maize starch or some other type of carbohydrate source, does there seem to be anything that shows a preference at least for gastrointestinal distress between different carbohydrate sources or what do you feel is some best practice for those athletes asking such a question?

Jamie Pugh: Yeah, so the thing that we found, so when we've done a little bit of a literature review and then when we've implemented it in some of the studies is that unsweetened, so often maltodextrin drinks are probably the ones that cause the least amount of symptoms. So we are looking at setting up a study where we may be looking to see if the sweetness of some of the high glucose or the drinks that have sweeteners added into them, if the sweetness and the taste maybe contributes to some of the nausea. But when we've given athletes in some of our studies, 90 gm of maltodextrin an hour – and if you've ever tasted it, it tastes of next to nothing, there's no sweetness to it, so that seems to be digested and tolerated really well, even at high concentrations. So

the options are glucose, maltodextrin, something that's quickly digested, rapidly absorbed in the small intestine, like I said where obviously that becomes if you are an elite athlete, that's easy enough and then you can sour your own drinks with your own feed stations like you can have your personalized drinks. As I said, when I've recommended this to recreational runners they will obviously turn round and say that's impossible because they can only drink something cool nine times out of 10.

Danny Lennon: One thing that did pop up when you were talking earlier about potential malabsorption causing issues here, I know some groups elsewhere have tried to look at things like the use of low FODMAP diets and does that do anything to try and combat some of these GI symptoms during exercise, have you looked at any of that work or have you seen anything that shows promise for that or whether there's no effect or have you seen any literature in that area?

Jamie Pugh: So within a couple of cities now off the back of some works, so it's preliminary work I would encounter again, it's one of the groups I think, Dana Lis, and they've shown that in a case study in particular the low FODMAP diet reduced symptoms in a symptomatic athlete. So I definitely think there's something in that, and like I said, it's something that again we didn't account for and we didn't manage to measure in our marathon study and that again is one of the potential reasons we think maybe we didn't see anything. And so even if you have two athletes who have the same carbohydrate intake that does not then necessarily mean that they can have equal levels of FODMAP in their diet. So it's definitely that level of information that we need to start going to. So for the moment, I think it's obviously difficult to recommend that as a blanket recommendation for all athletes during the training cycles because they can be quite restricted. But if you do have a symptomatic athlete, it's something we are looking into with a trained dietician to see maybe even in isolation or in the buildup to a major race.

Danny Lennon: Very interesting. It would be interesting to see what comes out from more of those studies. Jamie one thing I did want to circle back to was earlier you had mentioned that you guys had started to look at some of the stuff in relation to sports outside of endurance sport where primarily most of this has originally been done. What are some of the things that you saw when first looking at some of these other sports and maybe can you give us

an idea of what sports do you did evaluate and what sort of kind of prevalence rates you may have seen in those, etc.?

Jamie Pugh: Yeah, so we looked at quite a few sports, we looked at rugby league, rugby union, taekwondo, we looked at jockeys from horse racing, some professional cycling teams and cricket teams, and all the sports we went to, we went for international or premier standard, and so the elite of the elite in the UK. The prevalence was probably as high as what we've seen in some of the endurance athletes, which was quite surprising. Ultra endurance athletes maybe a different species, they have prevalence rates that are way beyond, but comparable to marathon runners, that's the sort of levels that we found. So we were looking, you know, around 20% of all the athletes reported at least one mild to moderate symptom, so that was maybe surprising because I think when you are looking at that level of severity, again that might just be some mild bloating after a meal or just some gas, something like that.

What was quite surprising for us was the fact that for every symptom that we assessed, so I think it's 13, 14, 17 symptoms, there was at least one athlete with a severity score of – so in this case it was six or seven but that was severe or very severe. So we made the argument that if that's the case in a group of athletes, these must be, we assume, speaking to some of the teams, these are issues that currently have been looked out or would have been picked up by a club or a national government body. And so we just said that maybe this is something that needs looking into a little bit more. If you've got athletes scoring a 7, so very severe for upper abdominal pain, that's something that probably needs further investigation. And so even just off the back of my research, I've obviously been asked for my opinion on a few things and even the last couple of months some of the stuff we've looked at and we go through and we go through best practice, but we look at their diet to begin with, we look at their history. And in two instances we had to refer onto gastroenterologists and the two athletes are currently going through screening now, because I don't think it's necessarily a functional gastrointestinal issue, it could be something clinical or pathological, it's something that requires more than just a nutritionist or a physiologist looking into.

Danny Lennon: Right. I guess the thing there, the fact that there is a non-trivial amount of people reporting symptoms and a number of them

with like you say, quite severe symptoms who have not really been getting any treatment for that, maybe speaks to that kind of prevalence or how common athletes sometimes can just view this stuff that it's not seen as a big enough issue that warrants going and getting this specialist kind of treatment unless they are advised by you or other people that are saying, hey, maybe we need to look at this.

Jamie Pugh: Yeah. No, I was really surprised. We looked at this and I've had it for like ever since I started the PhD we have it and the mild symptoms that can often be managed for nutrition, and you can try different things, and the joke was I always got 90 kilo rugby players whose wives have threatened them with divorce just because of the amount of gas they are producing every single day. And the nutritional events that we may be looking at setting up to try and combat that and try and help them and maybe their marriage. But then it's pretty [inaudible 00:35:13] like I said when you are – we've looked at athletes that after every intense training session there, on follow-up, they are reporting severe stabbing pains in their upper abdomen, and all they've had so far is nutritional advice or that that's how it's been combated and looked at, at the minute. It is surprising then that nobody so far has said, you know what, maybe we need to bring an actual specialist into this and we need observations and tests that we can't just do, we can't do here.

Danny Lennon: Yeah it definitely sounds like there's a certain scope for improvements for sure which is exciting as well. One thing I did want to get onto Jamie is some of the supplementation that you mentioned earlier on in the podcast, so maybe first if we turn to glutamine supplementation because I know you published a paper on it I think last year – and first of all before we get into the paper itself, why is glutamine typically discussed in conversations related to GI health and why is it something that we would look at in the first place?

Jamie Pugh: Yeah, so glutamine is one of the primary fields for the intestinal cells and the small intestine, so that's potentially why it's looked at so much so there's obviously a star older research that has looked at glutamine in endurance athletes and immune function, potentially with the full process that a lot of the immune system is based on and comes from the gut, but where the last few years of research has looked at oral glutamine to reduce the effects of exercise in terms of intestinal damage and that's something that

we looked at. So our study essentially was a follow-up of a previous study, so they gave – I am trying to remember the numbers off the top of my head, but they gave I think 0.9 gm of glutamine per kg of lean mass. So if you imagine for a 70 kilo athlete, I suppose that's 60, 63 grams of glutamine as an acute dose. So you are not talking small amounts. When we tend to replicate this, you are shuffling that into a bottle of water. So we just wanted to see was that a smaller dose that you could use. So this is just one of two hours before exercise, so we looked at 0.25, even 0.5 gm per kilo of lean mass. And we saw the dose response, so we looked at just exercise, running in the heat, and so we took the same markers that we've taken in some of these other studies and we showed a really nice dose response in terms of the attenuation and damage and permeability with this increase in glutamine. So we speculated that maybe smaller daily doses would potentially be effective, it would be nice to look at that. And even the practical application of that, I am not sure, I don't know of any ultra endurance athletes or any marathon runners who currently take these huge amounts of glutamine as a one-off before an event. It'd certainly be interesting to see the effects and do maybe a follow-up study to see how effective that would be either in reducing the likelihood of endotoxemia or GI symptoms as I said, particularly for some of these events in the heat. And so you do see these, even these high profile cases of heat exhaustion, exercise induced heat stroke and so maybe would glutamine be one potential way in which you could manage that to try and prevent that.

Danny Lennon: Yeah, I think that kind of idea of what dose could we use maybe more consistently, that's like you say a bit more practical and maybe a bit more cost effective than 63 gm each time, I think if you are doing that probably regularly.

Jamie Pugh: No, definitely, and it's something that I forget the exact paper of the study but it's something when I was just doing the literature before that study and sort of in a study they showed that if you continually use those large amounts of glutamine as supplementation, then the intestinal cell line can become almost reliant on that exogenous source, and so use less of the endogenous glutamine source. So the potential effects then if you wean off are probably not known, so I don't know if you maybe build up this reliance upon it if you were taking it regularly, and so it might be detrimental if you then just almost cut it out. So as you

said, it's finding a more manageable dose because it's not something I think you could do semi-regularly.

Danny Lennon: Right, yeah. That's really interesting about that essentially that negative feedback of just producing this if you are just relying on this huge amount, that's super interesting. Before we do finish Jamie I wanted to touch on probiotics which you also mentioned earlier. Where do we start here? What's the kind of at least the overview or cliff notes of where we are with the literature in this area and what you think is kind of safe to conclude in this area right now?

Jamie Pugh: Yeah, probiotics I think is I don't have the facts and figures but I was at a conference couple of weeks ago and they were describing how it's the fastest growing supplement within the industry and they were talking about the millions and billions that have been spent on research and development. So as an area it's fascinating and it's a difficult one when you come to read and look up on it just because on the one hand if you have strain specifics, obviously within probiotics we are talking about these bacterial not just species but strains, and if the benefits of strains specific, it's almost impossible then to compare studies unless they are either looking at two different strains competitively or if the two studies have used the exact same strain and the exact same dose. So it's difficult from that point of view to sort of then give blanket recommendations or sort of blanket conclusions about their effectiveness. So it's one of the things I've tried to say that when I maybe gave recommendations to team it was for athletes is that it's probably important to think of the measure or the sort of tangible that you have in mind. So if you are looking at traveler's diary or immunity or gastrointestinal symptoms, whatever it's going to be, if you are thinking of probiotics as a strategy for that, you probably need to go and find one that has been used specifically against that factor and that has been shown to be effective within your population group.

So that's where it is sort of from the broad sense that it's come from. In terms of gastrointestinal symptoms, there aren't that many studies that have looked at probiotics and symptoms within athletes. And so one of the ones which has was in fact it's from the company that actually sponsored my PhD. So that's probably going to get some people's backs up because they think it's industry funded, but I will just highlight that it was a real eye-opener in terms of industry funded research in that they literally

don't get involved other than give you probiotics. So they obviously don't have this hand in research design, research development, interpretation, any of that publishing results, so they don't actually see the results, and so it's published either. And so that was just at a little seem note, sorry, but as I said, one of the few studies that was looked at has actually come from the same probiotic, it's a multi strain, and it's the one that we've used in two of our studies now. So as I said there, they are currently under review but essentially we've shown that one, probiotics can affect exercise metabolism which we are quite surprised about can affect how much carbohydrate and potentially what carbohydrates or where it's come from, so we found that you can maybe increase how much exogenous carbohydrate you can oxidize or how much of a carbohydrate you consume with probiotics.

And then the other one, as I said, we did this marathon study and we showed that probiotics can reduce gastrointestinal symptoms both during training and the lead up to a race and then in a marathon race itself. And what I realized about that study was that even though it was a marathon we controlled everything, so we controlled what all those participants ate the day before the race, what they ate on the morning of the race. And then to really make sure that there were no confounding factors, we had a microphone and a stopwatch and every 15-20 minutes everybody had to consume the same gel and the same amount of water as well. So it was a really nice study to do and the benefits we saw can almost solely be put down to the supplement.

Danny Lennon: That's super interesting and I think it's going to be fascinating to see where more of that stuff goes for sure. One thing I did want to pull back on is I think you made an extremely important point that I think often gets lost when people try and talk about probiotics and supplementing and what they may be beneficial for is that that point you made about really there should be a targeted use of it and there should be some reason that someone is using it for, and once you have that reason then you can maybe try and look for a strain specific to helping that issue if possible or at least narrows it down in some way as opposed to this general idea of, well, probiotics are good and I will just kind of take any probiotic and it will be preventive for every sort of health issue under the sun, I don't think we are there yet with the research.

Jamie Pugh: As I said, and even if we were, I think it's still keeping a clear mind and so maybe not a scientific, pragmatic mind as with any supplements, so it's just good practice in how you treat any supplements. So if it was caffeine which has got a lot of research behind it for performance benefits, but you give it to an athlete and they get the jitters and they get a reduction in performance. You wouldn't then just continue to give them that, you would pull back or get a different source or something else. So even if that was a probiotic strain that comes out with robust research, you still like I said have to be pragmatic and say, well, right, we will monitor and how is it affecting our athlete, even if you are in a club with a budget, you still probably have to then go and see across the board what effect is it having on immunity or gut symptom or whatever it is. So I think yeah, probiotic is maybe on the sort of early stages of maybe what a lot of supplements have gone through in terms of their cycle and then first of all there's the everybody jumps on the bandwagon because it's a new exciting thing and research is coming out, and then as research comes out, that sort of pulls it back a little bit, you get this complete switch and everybody gets maybe a bit negative, and I think the truth is probably somewhere in the middle, and actually maybe just treat it as you would any other supplement, so you just have to use best practice.

Danny Lennon: Right. And I think that targeted use of something like a probiotic makes a lot of sense especially when you look at, at least what I've been able to pick up from just the general research in these areas is that seems that the benefits from a probiotics supplement seem to be whilst the person is using it and once it's discontinued you potentially can lose some of that or certainly those bacterial strains don't hang around in the gut and populate it the way maybe people previously thought they did or an idea that's kind of been promoted quite a bit. It seems to be more that it's during the supplementation, while that's ongoing, you are getting that benefit personally so I think that...

Jamie Pugh: Yeah, definitely, it is a transient thing and I think maybe that's one of the things that is coming out a bit more now is that even if it doesn't colonize, it can still be beneficial. So it will still be reacting and metabolizing within the intestinal system and so it will still be producing things like short-chain fatty acids while it's just in that, it's in transit, and as you said, so even if it doesn't colonize and you can still get these benefits.

Danny Lennon: Sure. I think we could probably spend a long time talking just about probiotics alone, so maybe that's another day Jamie, because we are just coming up on time here. So before we finish, maybe just to round this out, when it comes to maybe mitigating some of the issues that we've discussed today, if you were to leave just a couple of main takeaways in practice for maybe number one athletes themselves or two practitioners or sports nutritionists working with athletes, what are some of the pragmatic takeaways you would give in terms of mitigating some of these issues if they are present?

Jamie Pugh: Yeah, so the first thing is obviously considering the events, so if you know it's going to be hot and humid, it's going to be of long duration. One of the things we maybe didn't pick up on is that dehydration, over-hydration are big factors in terms of gut symptoms. So know the event and know the potential fueling strategy you are going to need and you are going to use. Once you know that, you can obviously then begin to practice it really looking, training that gut, so using products that you are going to use during that race, the same brands, the same amounts and the same timings, even getting to the l of the same pre-race dinner the day before if it comes to, if you are really worried about that. We know that some athletes seem to be almost predispositioned, so if they suffer once, they normally suffer again and again and again. If these are their mild symptoms or they have a slight effect on performance, then like I said, there are potential supplements, we've looked at glutamine, we looked at probiotics, there's colostrum, there are other things that you can consider taking that might reduce the damage that could reduce symptoms. I know we didn't touch on both staying away from non-steroidal anti-inflammatories. Again, we know that they can increase the damage and increase the risk of symptoms and just as you go along so there are some real nice case studies, anecdotes from ultra endurance athletes where they've documented that if they get symptoms or they feel that they are going to get symptoms, they can just switch and so they might turn to solid food rather than liquids. So I think they are probably some of the main ones to go with.

Danny Lennon: Brilliant. Thank you so much for that. So before I get to the final question, where can people find you online Jamie, more of your work on social media, any of that type of stuff?

Jamie Pugh: Yeah. So I am obviously on ResearchGate, I am on Twitter as well, so it's pugh_jamie, those are probably the best two places.

Danny Lennon: Perfect. And of course, I will link up to that in the show notes for everyone listening, you can go and click through those and read more of Jamie's work and read the full text to some of the papers we've discussed today as well as following him on Twitter as well. So with that Jamie, that brings us to the final question I always end the podcast on, 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?

Jamie Pugh: I am glad you said any area of the life, because it's not maybe exercise or science or nutrition related, but the one for me is, maybe this is quite cheesy, but just enjoy the things you do and it's something that particularly my family knows I do a lot is, I just try to laugh as much as I can. If you are not enjoying it, if you can't see the funny side of things, in some instances then I don't know what the point is.

Danny Lennon: All right. I absolutely love that man. So, I totally agree on that point.

Jamie Pugh: Well, we are having fun.

Danny Lennon: For sure man. I agree with that one a 100%. So Jamie, thank you so much for doing this man, I've really enjoyed this discussion, it's been amazing.

Jamie Pugh: Thanks again for having me. I really appreciate it. It's been great.