

**Katy Horner, PhD**  
**Gut Hormones,**  
**Gastric Emptying &**  
**Appetite Regulation**



≡ Episode 189 ≡



DANNY LENNON: Okay and we are live. Welcome to the podcast. I'm here with Dr. Katy Horner here at UCD, welcome to the show.

KATY HORNER: Thanks very much Danny, thanks for having me on.

DANNY LENNON: It's my pleasure. I've been reading, enjoying reading a lot of your research recently and some of the topics are ones that are of much interest to me sort of see some research on that that spans not only into food intake but also looking at the exercise component of that. I think there's two fields we're definitely going to dive into. But before we get to some of your research specifically can you just give these terms a bit of a background about what your work is on number one and then your own journey through academia and what that's kind of encompassed up to this point.

KATY HORNER: So currently I'm a lecturer in Sport and Exercise Science here at UCD. I've always been very interested really in everything in the field of sport and exercise and I did my undergrad BSc and MSc in Sports Science at the University of Limerick. After seven years in Limerick I then made the move to Brisbane in Australia where I was lucky to do my PhD with Professors Nute Burn and Neil King at Queensland University of Technology. And my PhD was in Exercise and Nutrition Sciences. I'm really interested in the area of exercise, appetite control and energy balance. So this was the

main focus of my PhD thesis and particularly looking at the role of gut physiology. Then after that I made another change which was a move to Pittsburg in America where I worked as a Postdoc at the Children's Hospital of Pittsburg. And here I was working on a NIH funded clinical trial looking at the effects of different exercise modalities on metabolic health and working with obese adolescents. So it was a very different setting and population group to before and following that I then moved back again to Ireland and I spent two years working in the Nutrition Biomarkers and Health research group here in UCD, working in the area of functional foods before starting my current position here as lecturer in Sports Science. So really my interest in research are in the area of exercise physiology and metabolism tied with nutrition.

DANNY LENNON:

Yeah, really interesting and lots to dive through. So one of the components that I really wanted to talk about was looking at some of these gut peptide hormones and how they affect appetite and then the role of physical activity and exercise there because just looking at some of the research papers you've published on this some pretty interesting concepts come up. But just maybe to get listeners all in the same page here, when we talk about these different gut peptides where that's things like peptide YY, GLP-1, hormones like ghrelin; number 1, what are some of these just to get people an understanding and maybe just a brief introduction to some things people should know about these types of hormones.

KATY HORNER:

Yeah, so they are very topical these gut hormones and they've really become researched a lot because of the influence of bariatric surgery really on these hormones. Drastic changes were shown with bariatric surgery and they were one of the mechanisms that were implicated to have a role in weight loss with bariatric surgery. So it stimulated a lot of research in the area of gut hormones. On the one hand we've ghrelin which is appetite stimulating hormone, it's the only known appetite stimulating hormone, so it generally rises before meals stimulating hunger and is suppressed after food intake. On the other hand we've hormones that could be termed satiety hormones, so these are released with response

to the presence of food in the intestine and these are hormones like glucagon-like peptide-1 or GLP-1 or PYY and these signal satiety after a meal.

DANNY LENNON:

So when we start to think about the influence of these hormones and I suppose their importance, the first thing I think that should come up is that obviously we have these hormones that change in response to food or lack of food that will drive our appetite or satiety for example. We have this kind of nice feedback system that should control food intake so considering all the health issues we have now that are related to excess body fat, accumulation and then obviously that coming from excess caloric intake or at least that's one part of the equation in terms of surplus of energy. It seems that there is probably something going on here, how can we have this kind of feedback of these things working to control how much we consume and yet such a problem with accumulation. So is it a fact that there's maybe some sort of dysregulation going with some of these hormones that then drives this body fat accumulation or do you think it could be the other way around that we're finding something that drives maybe obesity and overweight that then dysregulates those hormones or how should we think about this?

KATY HORNER:

Yeah, it's a very good question and I think it's important to put it into context. While these gut hormones do have a key role in food intake, there are so many factors that influence food intake. So our day to day food intake is really a combination of both homeostatic factors and also non-homeostatic factors. So we've disintegration of physiological factors such as gut hormones, gastric emptying. We've also psychological, behavioral factors, process of food reward that can also influence our food intake. So it's possible that these signals coming from gut hormones can be overridden by other factors in the current environment and there's also potential factors that could cause these hormones to become dysregulated as you mentioned. In the context of for example obesity or also an interest of mine that the role of physical activity so with sedentary lifestyles that this kind of homeostatic regulation of eating behavior can become dysregulated.

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DANNY LENNON: Yeah, there's a couple of things you mentioned there around food reward and gastric emptying which are two of the big components that I've seen in quite a bit of your research. So if we look at some of these things maybe first of all again just to clarify for people so we're all kind of clear before we get into the weeds on this, when we talk about something like gastric emptying, what exactly is that first of all? And then maybe second, how do you actually go about measuring that in a lab setting?

KATY HORNER: Yes, so basically gastric emptying refers to the rate at which food empties from the stomach into the small intestine. So it's basically the rate at which food is emptying from your stomach. It's measured in the lab setting in a variety of different ways. The gold standard method is scintigraphy whereby people eat a radioactive meal and their stomach is x-rayed over a number of hours as the meal is digested. So we can look at how quickly the meal is emptying from the stomach but this is obviously quite invasive, it exposes healthy people to radioactivity so it's not ideal in that context. The method that I used in my studies was called the <sup>13</sup>C caravan octanoic acid breath test. It's a non-invasive method just through breath samples. So I'll just ask people to blow into a tube using a straw and then to cap the tube. And they do this before the meal and then at intervals of four or five hours after the meal. And we put into the meal a <sup>13</sup>C caravan octanoic acid which is non-radioactive.

It's found naturally in various foods but we put in a known quantity into the food that people eat. When it's absorbed into the intestine, it's metabolized in the liver rapidly excreted in the breath. So the appearance of the <sup>13</sup>C caravan in the breath actually reflects the rate of emptying of the food from the stomach into the intestine. The gastric emptying is really the rate limiting step for its appearance in the breath so it's a much more friendly method. It can be used in babies, children, older adults and in a variety of different contexts.

DANNY LENNON: Yeah perfect, thanks for clarifying that and before we get into some of the effects of exercise with acutely and chronically in some of these things just again go over that other point mentioned a food reward before we look at that, how should

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people think about what food reward actually is? Because I'm sure they've heard it come up a number of times even on this podcast but how can we clear of or what are we talking about when we think about food reward?

KATY HORNER:

It's kind of referring to hedonic processes of food reward. So you might have heard of phrases like liking or wanting for different foods and so it's kind of the pleasure that is derived from food. How much do you like a certain food or how much do you want a certain food? So you may like a certain food sometimes but you may not necessarily want it right now.

DANNY LENNON:

And so we've got a number of different things that we've kind of touched on here. We have these different gut peptide hormones and they obviously influence appetite and satiety and we've talked about then food reward. We've looked at gastric emptying but the big thing that a lot of your work has focused on is the influence of exercise and the influence of physical activity. So to maybe start piecing through some of this stuff, where is the best place to start in, what have you been trying to answer with your research?

KATY HORNER:

Yeah, so the main focus of my research has been on gastric emptying. It's very intertwined with gut hormones as well which there's a lot of research in that area as well. So my interest was in characterizing the influence of physical activity on gastric emptying and its relationships with both body composition and energy expenditure. So for a long time over 30-40 years gastric emptying has been implicated to have a role in obesity that one hypothesis is that the faster foods empties from our stomachs, the earlier we get hungry and so we eat more. And there's been a lot of studies and a lot of high impact journals that have investigated this. They've compared lean with obese individuals and categorized them based on body mass index and some studies have shown faster gastric emptying obesity, some have shown no difference and some have in fact shown slower gastric emptying. And where I came to it from was we're seeing a lot more research now showing the importance of body composition, so fat and fat free mass and also physical activity level in metabolic health. And the

majority of these previous studies had focused on simply body mass index so I came with that kind of that approach to it. We're very interested in maybe physical activity level or body composition could explain some of the contrasting findings that we'd seen in previous studies. So we tested a group of 44 men; 22 were classified as inactive and 22 classified as active and we measured their resting metabolic rate, their activity energy expenditure with accelerometers and we also measured their gastric emptying and found that gastric emptying was faster in the active individuals and it was also associated with body composition and their activity energy expenditure but there was no association with body mass index. So it really kind of highlighted the importance of looking at activity energy expenditure and body composition when we're looking at factors involved in appetite control and gastric emptying rather than just this focus on body mass index.

DANNY LENNON:

Yeah, it's really interesting. You see that in a lot of areas now. It puzzles me that maybe there is not more attention paid to overall body composition as opposed to some of like...body weight is a good start if someone is going to look at that but I mean body composition can tell more in these cases.

KATY HORNER:

Yeah.

DANNY LENNON:

A couple of questions about that, so when you're stratifying them into the active and inactive, what are the kind of cut offs for what was deemed appropriate to put someone in that kind of active category?

KATY HORNER:

It was criteria that has been used in a number of appetite research studies. So they did a self-report questionnaire looking at their activity profiles over the previous six months and for inactive it was less than one hour in structured physical activity per week and inactive occupation as well. And for active as far as I remember, it was greater than or equal to four hours in structured physical activity per week and if individuals were in the middle somewhere they were excluded. We were trying to look at the two separate kind of ends of the spectrum.

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DANNY LENNON: So from the findings of that just outright it was the group of active men that had the faster rates of gastric emptying.

KATY HORNER: Yeah, it is.

DANNY LENNON: And obviously better body composition along with that. Based on what you found from that again like you said, previous research had been a bit conflicting, what were your initial thoughts or kind of hypothesis that kind of explain what you had seen in that research or was there anything that was kind of surprising to the people that you kind of came up with, here's some hypothesis that might explain what we've just seen.

KATY HORNER: Yeah, well I think it's interesting. Like some people might come to it and say well that's obvious just from general like ice age areas as well. There'd been one study in 1989 so a long time ago which looked at gastric emptying in 10 marathon runners compared to 10 inactive individuals and they found faster gastric emptying in the marathon runners as well. So our findings were consistent with that and marathon runners are a very specific type of group so what I was looking at was kind of general habitual physical activity. So people, rugby players, people doing cross fit, all sorts of kind of across the spectrum of physical activity, so it really just showed this influence of general habitual physical activity. The mechanism I think is a very good question. It could be we did find higher fasting ghrelin levels in the active individuals as well and this has been associated with faster gastric emptying in some studies of lean and obese individuals. So could be a gut hormone mechanism, also the role of the central nervous system and parasympathetic tone. So this is one of the mechanisms that is being proposed and we find as you'd expect the active individuals had a lower resting heart rate. Another mechanism is that it could actually be adaptive response to diet so if people have a higher energy intake maybe their gastric emptying is faster as a result but certainly our finding showed that it was the habitual physical activity level and the activity energy expenditure that was the determining the gastric emptying rates. I think there's a lot more to be looked at in terms of the mechanisms.

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DANNY LENNON: For sure, so when we're seeing there that we have generic people with a higher habitual activity intake have these faster rates of gastric emptying. On this side then of acute effects then of an exercise, what we know about how that influences things like gastric emptying.

KATY HORNER: Yeah, there's been a lot of research in the context of sports performance. As we know gastric emptying influences the rate of carbohydrate delivery to the intestine so it's very important in the context of sports performance. So in that setting, there's been a lot of acute studies and they generally show that exercise intensity is greater than 70% of the O<sub>2</sub> max. So at very strenuous, vigorous physical activity levels there's a delay in gastric emptying. So that could be one mechanism contributing to what's being termed exercise induced anorexia which is where we see at higher exercise intensities this kind of temporary suppression of appetite. At moderate intensities then the effects are less clear and at lower exercise intensities there's actually some studies showing that gastric emptying can indeed be faster, accelerated. So it seems to vary a lot depending on the exercise intensity.

DANNY LENNON: So I'm sure a lot of people listening have maybe heard before about changes from sympathetic to parasympathetic states or this fight and flight versus rest and digest mode, is that to some degree what might be going on in this super high exercise intensities in that the body is just shifting more of its resources away from digestion and that's what's leading to slow gastric emptying?

KATY HORNER: I think so, yeah. One of the mechanisms there in the acute exercise setting could be the changes in gut blood flow. So blood flow moving away from the gut to where it's needed more immediately. So that could be one mechanism. Other things like simply the jostling of the gut during exercise, simply the bouncing around of the gut could have a role as well as neural factors and gut hormones as well that we mentioned earlier. There's a meta-analysis by Matt Hubrish. He's done a few meta-analysis in the area and he showed changes in GLP-1 and PYY with acute bates of exercise that

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could be one mechanism. Again that's talking about mean changes in his meta-analysis.

DANNY LENNON:

Yeah, when this kind of conversation comes up around the effect of exercise on food intake it's really interesting because you hear these different ideas and different hypothesis come out. So we've seen here like very high exercise intensities for example the potential may be threat to cause maybe a decrease in what someone's going to take in based on how much of it is expended because of this change in gastric emptying. But then we also have people pointing to the suggestion that increasing physical activity is just going to cause someone's drive to consume more food to go up to account for that so hence why people tend to say exercise alone is not a good idea for purely weight loss. And again this is the kind of debated in different areas. Where do you kind of fall on this whole conversation around how exercise actually does influence food intake and does our energy expenditure...is that always just going to be accounted for by an increase in intake because of this or how should we kind of think about how this stuff plays out really?

KATY HORNER:

Yeah, I think it's a very interesting discussion point and it's a very topical one as well and I think it has been portrayed in some cases very negatively. In the media this relationship between exercise and appetite and it could be used and energy intake it could put people off actually engaging in exercise because of this belief that there is no point in expending energy during exercise because I am just going to make up for it in energy intake. But I really believe that that's not the case and it's very important. A lot of these articles kind of focused on some of the studies looking at individual variability in weight loss response to exercise. So the human appetite research group and energy balance at the University of Leeds where my PhD supervisor, Neil King, was based alongside John Blundell and Graham Finlayson they've done a lot of work characterizing individual variability in weight change in response to exercise. And their studies were very interesting because they brought people into the lab, they gave them the same exercise, energy expenditure every day. All the exercise were supervised in the lab so expending 500 kilo calories of energy every day for 12 weeks and they

showed some individuals losing as much weight as about 14 kilos and other individuals actually gaining weight, so some people gaining one or two kilos. The majority losing some form of weight but this huge spectrum of individual variability and some of these media articles have kind of picked up on the couple, the few individuals who maybe have lost less weight than expected and used it to portray exercise kind of in a negative way. But certainly the research shows with acute exercise there is no automatic increase in energy intake. Again when we're talking about the mean kind of response, when exercise increases over a number of days we do start to see increases but even when it does it only partially increases and not enough to compensate for the energy expended. But there is this kind of individual response and I think that's where it's really important that we learn how to characterize this rather than focusing on the negative. We try to understand what is happening to these people that they are losing less weight than expected that we could maybe if we better understand we can use it in future to develop better weight management strategies.

DANNY LENNON:

Yeah, I think that point is just so important of trying to look at beyond like the first conclusion people want to jump to of, oh well this is surely means that exercise doesn't really matter which is of course it's always going to be a bit more nuance than that like you said we have just individuals are going to vary. There's a really cool research, we talked to Dr. James Gill recently of how different ethnic groups have different changes. And then even what we mentioned earlier about if you have a study that doesn't account for body composition changes you may have especially if these people are new to exercise quite large increase in the body mass potentially you know exercise regime that might not be accounted for. So I think it's really interesting and one of the kind of hypothesis that I've heard talked about and I think was actually maybe mentioned in one of your papers that is again when it comes to either weight maintenance or weight loss why exercise may potentially be important is this hypothesis that there's, I suppose this bias of human physiology towards a higher energy flux. Can you maybe

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touch on what the hypothesis kind of hypothesis is and then kind of your thoughts on that high energy flux idea?

KATY HORNER:

Yeah, I think that's a very important concept to touch on. Epidemiological studies really consistently show that physical activity is crucial for weight maintenance and one of the hypothesis it's based on the early work of Myer is that individuals are better able to maintain energy balance at a higher level of energy flux or a higher level of energy intake and expenditure basically. The work of Myer was in the 1950s in India and he studied over 200 workers fairing in different occupations and he found that those with higher levels of energy expenditure were better able to match their energy intake to their energy expenditure than those in the more sedentary occupations like the office clerks. And in that kind of sedentary range we saw an actual in some case an increase in energy intake. So Professor John Blundell termed this sedentary range the zone of disregulation where it's likely that other factors are more likely to influence food intake rather than the homeostatic factors or physiological factors. And I think it's this role of physical activity here which could be crucial for the prevention of weight gain and also for weight maintenance whereby people are better able to match their energy intake to energy expenditure at higher levels of physical activity. There's some cross-sectional evidence of studies comparing active with inactive people and giving them high energy and low energy snacks in the morning and then looking at lunch time as to how they responded and those active individuals who had the high energy snack responded at lunch by eating less compared to when they had the low energy snack. But in inactive individuals there was no difference. They weren't able to respond at lunch time or compensate. So there's been more research since then all supporting that kind of view that more active individuals are better able to regulate their appetites and energy intakes were more close match.

DANNY LENNON:

For sure. I think maybe a lot of people might be listening and I've probably even seen the anecdotal whether that's with themselves or picked if they were a coach maybe that works with both athletes and maybe free sedentary individuals. What some athletes for example you take someone doing

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mixed martial arts or like a highly competitive cross fit athlete for example or just someone who is like regularly outside doing a lot of manual work. Like generally even if that person isn't tracking their caloric intake you see it's again going along with what the research is hinting at that it's easier a lot of the time for them to just maintain a healthy body composition whereas if someone goes into a phase where maybe they have stopped training through an injury or something or their work is ever sedentary for a while, they have to keep a closer eye on diet not purely just based on hunger changing in any meaningful way but it just seems like there is much less room for error or wiggle room there and I think kind of people have probably seen that anecdotally so it's really interesting that we're seeing that pop up in research.

KATY HORNER:

Yeah, I think so and I think it's very important to remember that as a beneficial office collectively as well that it is good to have these sensations of hunger and fullness and satisfaction with meals and within activity maybe the sensations can be blunted and we're not having that same physiological regulation, we're responding more to maybe hedonic influences or environmental factors or social cues rather than our own physiology. But physical activity could help to potentially keep us more in tune with our physiology.

DANNY LENNON:

So when we're thinking about how exercise can potentially affect food intake do you think it's important for people to think of maybe a longer window of time than they typically do because when people are making the argument that if you just try and exercise more, you're just going to eat more. They think of if someone goes for a really long run and they come back and then say that person is hungry at that time point. But maybe that doesn't tell us as much as what's going to happen later on in the day at their subsequent meals or even over the course of the next few days, over the course of a week when it's consistently done and it's a normal routine as opposed to what they are going to have acute responses once they get...do you think that's maybe where people are missing some of this conversation?

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KATY HORNER: Yeah, I think the combination of factors is the responses when people get home can be very important as well. There's some research showing that people that compensate for exercise by choosing high fat foods have sensations of food reward increase liking or wanting for high fat sweet foods after exercise that they lose less body fat with exercise than those that don't. So those immediate compensatory responses are very important to consider as well; what we do immediately after our exercise bates. But definitely in the long term, to look at the long term affects as well so one single exercise bates definitely does not have the same impact that repeated exercise bates do have on our ability to regulate food intake.

DANNY LENNON: Okay, perfect. If we start trying to tie some of this together for people listening, if you were to think about your research that you've done in this area, what are some of the kind of key things you would hope people would take away from kind of what we've discussed and what your research has borne out? And then maybe related to that, what are kind of some of the practical implications of some of these things that we've discussed?

KATY HORNER: Yeah, well I think definitely the importance of understanding this individual variability in weight loss responses to exercises not focusing on the negative but focusing on trying to understand why might some people be losing less weight with exercise than others. It's not just adherence those studies have shown, it's these people are being supervised exercise sessions in the lab so it's not just to be blamed on adherence. There's these compensatory responses changes in food intake could be one mechanism and a greater understanding of this is really important to enable people to use exercise more effectively in weight management. I think some of my own studies were looking at the role of body composition and activity energy expenditure in gastric emptying and appetite control and I think that's very important that we do consider the importance of fat and fat free mass and energy expenditure as well and they are very important factors really to look at.

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DANNY LENNON: Amazing. So for people that are maybe interested in diving into some of this in a bit more detail, can they find your research work online, maybe a research tape profile? Is there anywhere on social media that they can be following what you're doing or where is the best place for them to go to look at more of your work in a bit detail?

KATY HORNER: I have a research gate profile and I also have a twitter account as well. I think it's just @katyhorner, yeah.

DANNY LENNON: Yeah and I'll link that in the show notes for everyone listening so you can check that out and I will also link to as many of the research papers that are related to what we discussed today and that Katy has published. So with that Katy before we get to the very final question is there anything that we've maybe kind of skirted over here or haven't gotten to that you think is an important part of this conversation that you want to bring up or anything that we didn't really touch on in enough detail that you think is important to mention in this type of conversation?

KATY HORNER: I think I probably should have mentioned it in response to the last question about taking this multi-disciplinary approach to when we're looking at exercise and appetite and weight management is really critical. We can't just focus on good physiology or focus on food reward or focus on psychological factors separately; it's looking at the interactions between these. I think it's critical for a kind of getting a better global overview really of what's happening.

DANNY LENNON: Yeah, I can't agree more with that because I think so often when kind of people get into trouble trying to tackle this idea of how do we address obesity or overweight or trying to get people healthier over time. It tends to be where people get isolated on one specific area and then that tends to be where either diet fads grow or certain groups that have just one idea of how we're going to solve this thing whereas like you say there's so many different things that could potentially play a role and to think that this one thing is the answer is kind of a bit crazy, right?

KATY HORNER: Yeah, exactly.

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DANNY LENNON: Perfect. So to round us out the question I always end the show on, if you could advise people to do one thing each day that would have some positive impact on any area of their life what would that one thing be?

KATY HORNER: Well, I think it's probably been said a number of times before but I think the importance of physical activity and exercise just cannot be underestimated. Exercise has so many benefits which occur independent of weight loss so we often have this focus on weight loss but there is so many health benefits which occur independent of weight loss. So things like improvements in body composition, reductions in body fats, improvements in blood pressure, reduced risk of type 2 diabetes and improvements in mood as well and all of this comes from just exercising and physical activity. So just incorporating some form of physical activity and hopefully something that you enjoy into your daily lifestyle I think will have enormous benefits regardless of weight loss.

DANNY LENNON: Brilliant, another great message to end this show on. Katy we want to say thank you, number one for your time today, for hosting me here in UCD and for the great information you've given people. Thank you very much for coming on the show.

KATY HORNER: Thanks very much Danny.

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