
DANNY LENNON: Hey, Jorn, welcome to Sigma Nutrition Radio. Thanks for coming on the show.

JORN TROMMELEN: Hey Danny, thanks for having me.

DANNY LENNON: It's my absolute pleasure. I have been looking forward to this conversation because there's been quite a lot of work that, especially over the last year or so that you and your colleagues have published one paper recently only within the last month that came out I definitely want to dive into. Before we get to any of the specifics of that, maybe can you just listeners some context and tell a little bit about your background in academia and where you are up to this point.

JORN TROMMELEN: Okay. I am a PhD student in Maastricht University, and we have a pretty big lab that focuses on muscle metabolism. We have a variety of research interests. That is everything from glucose metabolism, so for example insulin sensitivity in diabetics or in elderly for example all the way to carbohydrate metabolism in athletes. So think of muscle glycogen recovery for example, but our main focus is probably protein metabolism, again in a variety of populations. So this is how do we keep the elderly strong so they can live independently; think of hospitalized patients, how do we keep them fit so when they get out of the hospital they can live on their own. Then again some of us are

more focused on the athletic population so people who go to the gym, how can we help them recover faster, build a little bit more muscle.

DANNY LENNON: I certainly want to talk about protein later on in the podcast but I have to start with the recent paper that you published only last month, I think it was titled Fructose and Sucrose Intake Increase Exogenous Carbohydrate Oxidation during Exercise. Before we actually get into the nitty-gritty of that particular study, because I think there's lots of interesting aspects to it, can you perhaps explain the purpose the purpose of the study or the question you are trying to answer and why it's relevant to exercise performance?

JORN TROMMELEN: Yeah, basically during exercise you want to provide your body with as much fuel as possible basically so you could perform better. Usually when we think about sugary products, we say oh that's very unhealthy and that's true if you are inactive. If you are couch potato, of course you don't want to have too much energy that you are consuming, but if you are an athlete it's the exact opposite, you want to consume as much energy as possible so you can perform at your best basically.

Basically, the traditional sport nutrition people think of the Gatorade drink or maybe a sports bar or gels and all those products are very effective. If you do prolonged endurance type exercise, carbohydrate supplementation is very effective. Your body stores carbohydrates of course. So yeah muscle glycogen, that's carbohydrates from your diet is stored in the muscle and you can store a little bit in the liver. But those carbohydrate stores are way too little for prolonged exercise. If you exercise say 2 hours and longer, at some point you just run out of your body carbohydrate stores and you basically want to prevent that by supplementing carbohydrates during exercise. So here's where your sport nutrition gels, drinks, etc. come in the picture.

You cannot simply just consume more and more because it would be nice if I were to run a marathon and I just drink more and more sport products and I would go faster and faster. Obviously, that's not a winning formula. The reason seems to be is that the

absorption of carbohydrates seems to be a limiting factor in actually burning those carbohydrates as fuel. So you can ingest them but they will just get stuck in your GI tract basically, and the reason for that is that the main carbohydrate in the diet and the main carbohydrate in all sport nutrition products is glucose.

However, glucose needs to be transported in the GI tract and it basically has its own entrance, that's how I like to call it as its entrance in the gut which is called the SGLT1 transporter that allows the glucose to go from the gut in the blood and then the blood transports it through the muscle where it can be burned for fuel, which we call in this case glucose oxidation. However, that transporter gets saturated at high glucose intakes, so most people can absorb about 1 gm of glucose per minute. If you take more glucose than that, all that happens is you can see it as an entrance. If more people try to go through the entrance, then people can actually go through it. All would happen is that they would accumulate outside of the entrance.

Exact same thing happens in your GI tract. If you consume too much glucose, it will simply accumulate in your gut and you would get very sick. However, there's a trick to increase your carbohydrate absorption rates and this is by using a different carbohydrate source. In this case, fructose, which is a different dietary sugar, and it uses a different transporter called the GLUT5 transporter so it's basically a different – an additional entrance in the gut. If you ingest combination of glucose and fructose you use both of these transporters in the gut and therefore you can absorb carbohydrates at a higher rate and therefore more carbohydrates reach the muscle and more carbohydrates can be burned during exercise, and as a consequence you are less reliant on your body's own carbohydrate stores.

Now, it's very interesting is that sucrose which is just regular table sugar that we put in coffee for example, that's a disaccharide meaning that it contains one part glucose and one part fructose. So sucrose is basically a natural carbohydrate source that provides that optimal blend of the two different types of sugar molecules. In this study we basically wanted to see is

– basically good old stable sugar, is that not a very effective carbohydrate source during exercise. We did a study where well-trained cyclists came to the lab, each of them came four times, did four times the same exercise test. Once, while they received a sport drink that's consistent and daily out of glucose, then a second time they came and they got a drink that contained glucose but also fructose – showed the carbohydrate blend basically. Third time they came and they got a combination of glucose and sucrose and the sucrose was provided in an amount that if the sucrose would be properly digested, it would provide the exact same amount of glucose and fructose as the second treatment and then the fourth treatment was a water placebo.

So this design basically allowed us to see if indeed the blends of carbohydrates, if they were absorbed faster and burnt at a higher rate by the muscle and also if the sucrose was just as effective as providing those two carbohydrates sources separately. So our subjects cycled for three hours at a steady state and during this time we collected [rat 00:12:28] samples and that allowed us to calculate how much of the sport drinks that they ingested that they actually burned. We saw very clearly that the glucose in drink leveled off at about 1 gm per minute, so about 1 gm of glucose was burned each minute during exercise which is perfectly aligned with the theory that you can only absorb 1 gm of glucose in the gut. Then the two other drinks, so it didn't matter if we gave fructose as a free sugar or it was provided as part of sucrose, both those treatments resulted in about 40% higher carbohydrates oxidation rate. That suggests that the absorption rate in the gut was about 40% higher and that you basically could use 40% more of your sport drink as a fuel during exercise.

DANNY LENNON: If we take that and then think about the comparison between using that glucose and fructose mix versus say using sucrose, does it tell us anything about – from a practical level of say athletes are going to go and try and put some of this into practice – about do they need to think about the ratio of glucose to fructose that's being used in a certain drink? What kind of ratio did you use in the study and what you

think at a practical level the significance of the ratio between those being at the actual end result?

JORN TROMMELEN: Well, we used a ratio that has been used the most in research which is a 2 to 1 ratio, so 2 molecules glucose for every molecule fructose. But there is some research that suggests that a little bit of closer ratio, so a little bit closer to 1 to 1 might be a little bit better. But yeah, there's not enough done in that area to make really solid recommendations. But my guess would be that if you would take pure sucrose it would do about the same as a mix of glucose and fructose.

DANNY LENNON: Just to recap on a couple of I think very important points that we've outlined so far, number one being that we can kind of conclude that solution of glucose and fructose mix is absorbed at a faster rate in the gut and is more effectively oxidized for energy than if we consume the same amount of carbohydrates provided only as glucose. I mean, this being the high levels that we would be using to say replenish glycogen or something. But at a certain level we are getting a beneficial impact from the glucose and fructose mix due to being able to more effectively oxidize that for energy. Second, and kind of related to that, if there is too much glucose taken at the one time in a very large bolus dose because of the effects on how quickly that can be absorbed in the gut, if we are taking too much, then that can leave glucose sitting in the gut for a period of time and presumably this is where maybe athletes who have experience of this having gastrointestinal distress from consuming lots of carbohydrate gels or carbohydrate solutions when they are particularly in endurance sport – is this kind of the reason why they would experience some of these gastrointestinal distress issues, because the glucose would end up sitting there in the gut?

JORN TROMMELEN: That's correct. In our glucose-only group – so in all the three carbohydrate treatments the total amount of carbohydrates was kept the same, but then in the two blend groups, so the glucose plus fructose or the glucose plus sucrose we still wanted to have enough glucose to saturate the glucose transporter. Because if you give very small amounts of glucose and fructose it's not going to be better than glucose because there was no limiting factor for the glucose anyway, right.

So this concept of a carbohydrate blend only becomes relevant at relatively higher intake levels when glucose absorption becomes limiting and only then the incremental benefit of fructose becomes apparent. But as a result, because we wanted the glucose intake to be high enough to saturate the SGLT1, so the glucose transporter in the gut, it means that in the glucose-only group, the total glucose intake was much higher, because we wanted to keep the total carbohydrate the same. In that group, we saw that all the subjects were struggling quite a bit, almost all of them had considerable GI complaints during exercise while during the two blends carbohydrates trials and this was hardly the case.

DANNY LENNON: There's something very important that you mentioned there Jorn. I think it would be good to clarify and dig into a bit deeper. When you talk about exogenous carbohydrate oxidation and I suppose there's really two parts to this question, the first being, number one, why is it so important to look at exogenous carbohydrate oxidation as opposed to simply just the total amount of carbohydrate that was oxidized. And then second and kind of related to that, how would you go about distinguishing between the amount of exogenous carbohydrate that was oxidized versus simply the total amount of carbohydrate oxidized when you are actually looking at this in the lab?

JORN TROMMELEN: If you measure total carbohydrates oxidation rates, so this is what is traditionally done. I think that most nutrition or exercise students will do this in college – use indirect calorimetry and basically by taking breath samples and by measuring how much oxygen you consume and how much CO2 you produce you can calculate what was the fuel source that I burned. That's because carbohydrates and fat, they require different amounts of O2 to be consumed and different amounts of CO2 will be produced when you burn them. Based on breath analysis you can see is the body burning fat, carbohydrates or a mixture of both and how much of both.

But the problem is if you only measure carbohydrates' oxidation rates. Is it good or bad if carbohydrate oxidation is high? I don't really know because ideally I want to have my glycogen oxidation as little as

possible because we already mentioned we only have a limited store of carbohydrates in the body and once you are out of that you are entirely reliant on body fat and your performance will dramatically drop. So ideally you want to use as little of your stored carbohydrates so you always have that as reserve and burn as much of the carbohydrates you ingest during exercise, because you can always ingest more right. So you want to separate those two, you want to keep exogenous, so that means from outside the body, the carbohydrates you ingest, you want to keep that as much as possible or as high as possible while you keep endogenous carbohydrate oxidation so your muscle and liver glycogen oxidation as low as possible. How can you separate those two? We use that by adding tracers in the mix.

So tracers is basically a fancy word of adding something to your measurements to trace a biological process. So normally, when you measure carbohydrate oxidation, basically if you take the molecular formula of glucose, it's burned with oxygen and you form $CO_2$ and $H_2O$. What we do is we give our subjects a special type of carbohydrate. It's still regular old glucose and regular old fructose and regular old sucrose but it basically has a molecular signature on it.

What we do is we use carbon atom that weighs a little bit more, it's functionally identical, thus exactly the same thing in the body. However, on a machine you can see oh this carbon atom weighs a little bit more than a normal carbon atom. We give our subjects these carbohydrates that weigh a little bit more but only on a molecular level. So what happens is when these carbohydrates are burnt you produce $CO_2$ just as you would with normal carbohydrates but now the carbon atoms in the $CO_2$ have this molecular signature, because it's basically the same carbon, it's the carbon atom from the carbohydrates that during the oxidation process is then transformed in $CO_2$.

The amount of that molecular signature that we measure in the breath of the subject, we know that that can only come from carbohydrates that we provided, the special type of carbohydrates with that molecular signature. By adding that tracer in the mix

we can now measure this is how much is burned from the drink that is ingested, we can calculate the total amount of carbohydrates and then the difference is the endogenous carbohydrate oxidation rate and so we can separate the three.

DANNY LENNON: Awesome. So far Jorn we've talked about this discussion of the type of carbohydrate mix to consume based purely on an oxidation of those carbohydrates to fuel training performance. But if we were to switch gears maybe and consider another scenario where people are going to probably consume high doses of concentrate carbohydrates, like this particularly in athletes, would be around glycogen restoration or glycogen re-synthesis and trying to top their levels back up after a training session. So does the same idea hold true in that for optimal glycogen re-synthesis should people also be thinking about using a glucose-fructose mix as opposed to purely glucose or something like that, if it comes down to glycogen restoration and glycogen re-synthesis after a training session?

JORN TROMMELEN: Yeah. Good question. Of course we also did some research in that area. In theory, the concept should also hold true for recovery. But let me go one step back, let's go back to carbohydrates ingestion during exercise because it's a little bit more complicated than we now made it seem. Now we said if you add fructose to your glucose, because it's absorbed differently, you can absorb carbohydrates at a higher rate and therefore you can burn more total carbohydrates. But there's one intermediate step because the fructose is absorbed via the different pathway in the gut and then it's transported to the liver. But the liver actually does not release the fructose as fructose. The liver converts the majority of the ingested fructose into a lactate.

Now lactate has a very bad reputation and it's often blamed for that burning sensation during high intensity exercise and it's supposed to cause fatigue, but it's actually not true. In fact, the opposite is true. Lactate is a fuel source for muscle. So muscles actually burn lactate as fuel source and that's exactly what happens in my study. After fructose co-ingestion, we see that lactate levels go up. However, this is a good thing because it means there's more fuel available for

the muscle. Basically, the fructose is converted into lactate and then the lactate is burnt as extra fuel. This is relevant for the post exercise recovery story because in theory the same concept should hold true, more carbohydrates are absorbed during post exercise recovery.

Then again, the fructose is converted into lactate but the big difference here is, is that well lactate is a very effective fuel source for muscle. It's not a good building block for muscle glycogen. After exercise, fructose co-ingestion doesn't increase muscle glycogen recovery, simply because it's not the proper building block for muscle glycogen. However, fructose like I said, after it's absorbed in the gut, it's transported to the liver but in the liver there's also glycogen recovery and fructose is very effective at restoring liver glycogen.

We did two studies, one to see if fructose co-ingestion would improve muscle glycogen re-synthesis rates after exercise but that unfortunately didn't work. However, we also did a study where we measured liver glycogen repletion rates and that was increased when fructose was co-ingested. In the end, yes, both during and after exercise there is a beneficial effect of fructose co-ingestion.

DANNY LENNON: Thanks for that Jorn. That provides a lot of really good context for this discussion, but just to switch gears I am keen to dive into some of the research that you've looked at on protein, particularly on protein timing and distribution, how that affects overall muscle protein balance. I think most people who have looked at research in this field will recognize that the lab that you are in, pretty much one of the world leaders in this area, so I am very keen to talk about some of this. It's been an area that has been discussed a number of times on the podcast previously. We've looked at really a number of different issues related to muscle protein balance and how that might translate to either muscle hypertrophy, muscular recovery, sarcopenia, etc. etc. Those regular listeners that are listening now will maybe remember episodes with Donald Layman, Caoileann Murphy, Joseph Agu, Brendan Egan, Kevin Tipton. We've all discussed some of the deeper research looking at protein

intakes, protein distribution, muscle protein balance, etc. etc. and all those related things. Where I think I really want to get your input is on this issue of consuming protein pre-sleep because I mean over – I don't know how many years people have talked about this recommendation of consuming some protein before bed, particularly casein protein because it's slower digesting. With the view that mechanistically this makes some sense in that you are trying to maximize the amount of muscle protein synthesis over the course of the day or provide enough amino acids over the course of the day and before that period where you are going to go to sleep is going to be something like a 7 or 8-hour window where you are not going to be able to consume any nutrients. And so people are kind of familiar with this concept of well, casein protein, particularly, or some sort of protein before sleep. Now, in some of our previous discussions we've kind of looked at the back and forth of what might be going on here and really you and your colleagues at Maastricht have been the ones who have really been in the forefront of actually examining this, at least in a way that I think is able to accurately assess this question of whether pre-sleep protein consumption has a benefit. Essentially, trying to distinguish whether the benefits of consuming some protein pre-sleep are actually due to a benefit of that specific timing or is it just simply due to an increase in overall daily protein intake that many other studies have end up providing. So they add in a group that consumes a pre-bed protein supplement and they see a benefit for MPS, so they see a benefit for muscle hypertrophy or lean mass retention, etc., etc. but it's with the caveat that that group's total protein intake is higher than the other group that didn't get it.

Now, for the research that you've done to try and control for these things, to restart us off on discussion, can you talk us through some of the work that you've done on the topic that might be able to reveal the answer to us as to whether pre-sleep protein intake actually is something that's going to have a benefit to people who are trying to say maximize muscle hypertrophy or recovery and what you think based on the research we should be able to conclude from this.

JORN TROMMELEN: Yeah, so I will go for the basics real quick and then we can have some more fun discussion about the harder questions. Basically, we did a study where people had their normal habitual protein intake during the day, did a session of resistance exercise in evening, got an optimal amount of post-workout nutrition, so 20 grams. And then about two and a half hours later they went to sleep and then they slept for about seven and a half hours. Then one group got additional protein prior to sleep almost 40 gm of casein protein. The other group got simply a water placebo. We found that even after that day of normal protein intake and post-workout protein supplementation that additional protein still had an additional benefit and increased overnight muscle protein synthesis rates.

Then we more or less did the same study, the same concept but now we did a long term study and the study's subjects trained three times a week for 12 weeks resistance exercise. Again, we saw that the group who got additional protein prior to sleep built a little bit more muscle. Now, the question, like you mentioned then becomes is pre-sleep protein just super effective or is it simply because they eat more protein. That's a very difficult question scientifically to answer, because most people are pretty shocked when I tell them that about 80% of all studies where one group gets additional protein, compared to another group that just gets a placebo that there's no difference in muscle gains between those studies.

A lot of people say oh yeah in your study – the ones in my study – in our study oh yeah, you give more protein so of course they are going to grow better. But it's actually not the case. In the vast majority of the cases, additional protein doesn't do so much, and that's not because protein is not effective, because what we did is we put all protein supplementation studies in a meta-analysis and what we then saw is that in all those studies it always seems that the group with additional protein does a little bit better than the control group, just not enough to get a significant result, but you see it very consistently.

The basic principle is if you flip a coin and it's head three times in a row, you say ah that's just luck or bad luck. However, if you flip a coin and it's 20 times

head, then you are like maybe there's something to this coin that it always flips head. It's the same thing with protein supplementation studies. It's very difficult to do a study that's big enough because they are very expensive and they also dramatically are different when you compare them just the cost of which analysis you do. So often you hear that a DEXA is a very good tool to measure muscle mass but it's actually quite poor.

In our pre-sleep protein study we had three methods of measuring muscle gain, a DEXA, a CT scan and a muscle biopsy. On the DEXA scan we found no significant improvements in lean body mass. While the other two methods which are much, much, much more expensive we did find an increase in muscle mass. But almost all studies only use a DEXA or even a worse method because of costs.

The point I am trying to make is, additional protein is already really difficult to clearly show in a study that additional protein helps to build muscle. It definitely works but just very difficult to show it in one study because it needs to be huge. If that's already difficult to show, how are you going to show that for example additional protein prior to sleep is better than protein at a different time point? Because if it's already difficult to show that protein compared to a placebo works, now you are going to compare protein to protein at a different time point, which of course the difference between those two treatments is smaller. It's very difficult scientifically. Basically, it all comes down to money. Just very difficult to pull that study off. It would simply cost way too much.

However, we have recently done a study where we gave subjects a large amount of protein during the day and also gave them an additional 60 gm of protein prior to sleep. Well, one group got an additional 60 gm of protein prior to sleep, the other group got nothing. Then the next morning, both groups got the same breakfast with protein in it and then we saw how do these groups respond to the breakfast. We saw there was absolutely no difference in muscle protein synthesis in response to the protein-rich breakfast.

That study basically shows that the protein you eat earlier in an earlier meal doesn't really influence the response to a next meal. So the takeaway from that study is that every meal is more or less a unique window of opportunity. Your breakfast, you should eat enough protein to maximize muscle protein synthesis rates until your next meal which usually will be lunch. Now, lunch you should eat enough protein to maximize muscle protein synthesis till your next meal probably dinner. Then dinner, you should eat enough protein till your next meal. What's your next meal going to be? For most people that's breakfast. Then the question is how confident are you that your dinner is going to maximize muscle protein synthesis rates for 10, 11 maybe even 12 hours. I wouldn't be so confident.

So I think that by eating additional protein it's absolutely additional. I see no reason to recommend someone oh you should cut – what are you doing now – oh maybe you should cut some protein from your breakfast and move it there. There's absolutely no reason to ever eat less protein at a meal. By eating additional protein prior to sleep you basically have two birds for one stone. You are introducing additional protein in your diet, that's always good, and you are introducing it at a moment that basically from a protein distribution standpoint is very beneficial. Pre-sleep is the longest period that you cannot eat a new meal.

Just very pragmatic I think it's beneficial to eat pre-sleep protein. I don't think if you would do a study where you compare pre-sleep protein versus for example extra protein in the morning, my guess would be that there's a very small benefit for the pre-sleep protein, not because there's something magical about the night, it's only because the night is for most people the period where they have the lowest plasma amino acid levels. If you would compare pre-sleep protein for someone who eats a huge dinner in the evening, but skips breakfast, for that person I would recommend 2 no, make sure that your additional protein is in the morning. So basically, my recommendation is just try to distribute your protein as good as possible, it's probably not the most important determinant of muscle gains. That's

probably total protein intake but you might as well try to distribute it as good as you can. For most people that means adding a little bit of protein pre-sleep.

DANNY LENNON: And so when we look at those recommendations for protein doses per meal to stimulate MPS, I think at least most of the research that I can think of is recommending somewhere between 0.25 gm per kg or up to maybe I think highest would be like 0.4 g gm of protein per kg of body mass. And again feel free to correct me with any of that if I am wrong. But regardless of what the actual number is, when we are looking at those typical doses for protein recommended to distribute throughout the day – because of the lag time that you mentioned that we are going through overnight because of an extended period of fasting, regardless of whether we have definitive proof or not, do you think purely based on someone who wants to tick all the boxes, it's no big deal where they put those meals and they are just trying to do every single little thing they can to maximize say muscle hypertrophy – do you think then that theoretically at least the pre-bed meal of protein should contain an even higher amount of protein than those recommended doses based on that lag time that there is going to be overnight?

JORN TROMMELEN: Yeah. I definitely think it's worthwhile to add a little bit extra. The amounts of protein you mentioned, those are correct for young and elderly people respectively. However, those response studies have typically been performed and then muscle protein synthesis after such a protein dose was measured for 4 to 5 hours. In contrast, the overnight periods, it's 7 to 8 hours. So we have now two papers under review. I cannot say too much about them but both of them indicate that it's probably wise to eat a little bit larger amount of protein prior to sleep than in a standard meal. Again, it depends on the conditions. If you just happen to be one of those freaks who wakes up after 5 hours of sleep, then there's really no need for that additional amount, but if you have the standard 7 to 8 hours of sleep, I would aim at least 30 gm, that's the amount we used in our long term training study and that definitely promoted muscle gains. But based on some research that hopefully is out soon I would

suggest that 40 gm is probably better. So yeah I would try to go a little bit higher.

DANNY LENNON: Okay. And so provided that it's a what we would consider a high quality protein source, so typically an animal source of protein and so really something with just really good amino acid profile, so whether that's whey or casein or beef protein whatever, do you think there is any need for someone to kind of worry about the differences in the type of protein they are going to use at that time point or once the dose is sufficient, particularly of like we say a high quality protein, animal protein source and say leucine is sufficient, do you think there's any real need to worry about differences between whey or casein or beef or egg, etc. or is it going to be really the same net impact at the end?

JORN TROMMELEN: Yeah, that's interesting. A lot of people have claimed that we are pushing casein. I have no clue why they think we have ties to companies but whatever. And then the idea behind casein would be is that's a slowly digesting protein source, so it would provide amino acids throughout the whole night. But the reason why we have used casein in our studies is actually – it has nothing to do with companies or whatsoever – it's actually because we use a special type of protein and it's the same concept we talked about earlier with carbohydrates. We use special protein that has those atoms with those molecular signatures so we can do all kinds of fancy measurements basically. And to produce that it's – when you produce that, you basically produce a lot more casein than whey. Basically, every time we do it, and that process is incredibly expensive. People always think that we do those one-day studies because it's cheaper or easier than the longer training studies for example but just producing that protein is more expensive than 99% of the studies out there. We produce that special protein with that molecular signature and that's just more efficient to do that with casein. That's the only reason why we have used casein so far.

To come back to your question, I did a study where I looked if adding leucine to casein helps to improve overnight muscle protein synthesis. Again, that's still in the review. Leucine is basically the amino acid and

protein that's the most potent at stimulating muscle protein synthesis. By giving this amino acid as a free amino acid, it doesn't require any digestion. So basically when you add the free leucine to casein, you are basically mimicking a fast protein because that leucine is going to enter the circulation right away, so your leucine peak with free leucine co-ingestion is actually higher than when you would have given whey. But I saw there was no difference when I gave casein versus casein with additional leucine. BASED on that I don't think that a fast or a slow protein source will make a huge difference and like you said it's probably make sure that you have a good quality protein, so an animal protein source but I wouldn't stress too much about which protein, which animal type protein. I would do whatever is most convenient for you.

DANNY LENNON: Jorn one more topic I did want to get onto before we did finish up was on one of the papers that you published last year that I remember reading was examining this idea that potentially resistance training performed in the evening time could augment the overnight muscle protein synthetic response to the pre-sleep protein ingestion that we just mentioned. Could you maybe just talk a bit about that work that you did and maybe zero in on some of the mechanisms that you think by which resistance training in the evening is allowing for this increased protein synthesis overnight.

JORN TROMMELEN: Yeah, so we basically wanted to see if you did exercise earlier in the evening, so not directly before your pre-sleep protein but just earlier in the evening, if more of the ingested protein prior to sleep would end up in the muscle and indeed, it does. What that shows you is that if you do resistance exercise your body utilizes the protein you ingest prior to sleep more effectively and again we could measure that with that molecular signature technique, because normally if you take a muscle biopsy you just see muscle protein, you don't know what it is, where it comes from, but then if you take a first muscle biopsy, you don't see any of that molecular signature and you give that protein with the special atoms in it and then you see all of a sudden these special atoms are built into the muscle protein, that means the protein is used to build muscle. Then we did that once when people didn't do any exercise

prior to sleep and the other time when they did do exercise prior to sleep. And then when people did do the exercise prior to sleep a lot more protein mated into the muscle.

Now of course this is nothing new. We all know that exercise is anabolic for the muscle but yeah, it's nice to show that the synergy between both protein and exercise also works during the night and the practical takeaway from this is that if you don't really like supplements try at least to take some additional protein that can also be a dietary food source on training days because that will be especially effective. But even on non-training days protein ingested prior to sleep will still end up in the muscle.

DANNY LENNON: Thanks for that breakdown Jorn, it's really fascinating stuff. Just before I get to the final question to wrap things up, maybe just let people know where they can find more of your work online and check out more of the stuff that you are doing.

JORN TROMMELEN: I have a blog called nutrition tactics and I have a Facebook page where I try to post just a short commentary when there's some irrelevant sports nutrition or exercise research. So those two are probably the best spots to look for me. So again that's nutrition tactics, but I am on all social media, but on those two I am the most active and if people have any questions I remember that not that long ago I was just a college student and I was super excited when a researcher answered my question so I always love answering questions. Please ask them and I always like it when subjects – when people are critical, so if you think that's all nonsense I have said, just comment and we will have a nice discussion.

DANNY LENNON: Awesome. Yeah, for everyone listening I will post a link to all of that stuff that Jorn just mentioned in the show notes to this episode which will be at sigma.nutrition.com/episode174. So with that Jorn we come to the final question that we always end the show on, and it's simply, if you could advise people to do one thing each day that would have a positive impact on some area of their life, what would that one thing be?

JORN TROMMELEN: Try to be as humble as possible in anything. So I always wanted to be more of a sports nutrition practitioner. I just couldn't wait until I started to work with athletes but – so I read all the papers in college and I never was fully satisfied with – I kind of read papers and like oh whey is better than casein, that's interesting but I was never satisfied like ah I don't fully understand how they measure this, like what is this guy talking about with these special atoms right. So that's on a career level but with everything, try to be as humble as possible and then that way that's just the way to learn. If you stay humble, 10 years later you will be somewhat successful and keep learning. So don't be too impressed by yourself and I think that's a good way to make progress. Same way in the gym, if you are too happy with the body you have or your strength stats, you will stagnate, be humble, train with people who are stronger and bigger than you and you will continue to improve.

DANNY LENNON: Yeah, great stuff and I completely agree with that Jorn. So with that I just want to say, thank you for taking the time out to do this today and to give the great information that you've done and for the continued research that you are carrying out to help us further in the area of sports nutrition. It's very much appreciated, so thank you for all you are doing and thanks for coming on the show today.

JORN TROMMELEN: Yeah, thanks for the invite.