ICSC Culture Diversity Module 08
ICSC08 _ Section 2_Exercise Physiology
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Video Lesson: 01:50:34

Welcome to the second section of the Exercise Physiology for Fédération Internationale de Chiropratique du Sport. One of the things that we will be looking at for this session is the metabolic pathways of energy production. Then we will investigate aerobic conditioning.

We will begin with an introduction to energy transfer. When we are talking about energy transfer, we are talking about either a quick type of energy or something that is long-lasting. For our immediate energy needs, we talk about phosphate bond energy which is ATP. We have about 100 grams of ATP in our body, there is not a lot, which is a good thing because that means if you have a decrease, the percentage automatically kicks the body into higher energy production. You can see the ATP broken down to ADP and phosphate, so the high-energy phosphate bond is broken. That is where we get our energy. The enzyme will be ATPase. One of the things about metabolic pathways is that enzymes are very important. The environment that they operate in is very important. These are some of the training adaptations you will get with conditioning.

There is a reserve, the phosphocreatine is in reserve, and phosphocreatine when you combine it with the ATP that was broken off will give you more ATP and creatine. The enzyme here is creatine kinase. This is an enzyme that is important. You will see this in blood reports. This is an enzyme that is at very high levels after heart attacks because of the damage to the muscle.

That is a very important enzyme, and we will talk about the environment that the creatine kinase has to work. Then we look at the adenylate kinase reaction, whereas you take two of these ADPs, and you can get one ATP and one AMP. AMP, adenosine monophosphate, activates the initial stage of glycogenolysis and glycolysis. Basically, your AMP is a messenger-type molecule. If you are latency, we use ATP.

We are using ATP right now as we sit here. As we need more energy, we can dip into the phosphocreatine stores. After you dip into the phosphocreatine stores, you are going to start getting some production of ATP through the ADP, the adenylate kinase reaction, that is where the cyclic messenger will tell the body, "Hey, it is time to ramp up. We are going to need more energy."

One of the things we want to look at in terms of metabolic pathways is, “what are some of the nutritional supplements that fit into this area that people are trying to use or trying to sell us?” The first one we will talk about is creatine monohydrate which the theory is it enhances anaerobic power, enhances strength, and speeds recovery from interval work. We will want to look at dosage. We will want to look at the effect of caffeine on creatine. One of the first things we should ask ourselves if we are looking at the supplement is “is this something that is even legal to use?” In fact, I know the International Olympic Committee (IO)C allows it. You must check with your individual organizations, whether it is government or sports federation.

For example, here in the United States, one of the strange rules is it is legal at the college level but the National Collegiate Athletic Association (NCAA), says that trainers and strength conditioning coaches cannot provide it for the athletes or cannot supply it, which I think is an odd request. I think in the Minnesota High School Athletic League where I live, the High School Federation here, they say, "No, you cannot use it, but no one tests for it." But they do not say it is legal, they just say do not use it. T

here are some grey areas in there. But in terms of research, it is one of the supplements that have gotten some of the best research in terms of usage and beneficial effects.

Let us just look at daily activity. You need about two grams of creatine daily just to perform your normal activities in terms of supplementing the ATP. A typical diet that includes meat provides one to two grams of creatine each day, so you are almost getting what you need for activities of daily living. If you supplement but you are not working out, it does nothing. For women, that means getting 46 grams of protein daily, while men need 56 grams of creatine each day. Which, once again, if you are a meat eater you are going to get on a normal day.

Here are some of the theories behind creatine supplementation. We were pretty sure it works but we are not quite sure how it works. Here are some of the theories that we are looking at. It increases high-energy phosphate metabolism. That is true. I should not say we do not know what it does, but we are not sure what the percentages are and if it is the same for everyone.

It does seem to increase satellite cell activity, which we have discussed how important satellite cell activity is for the repair process of the muscle. It seems to improve cellular hydration status, and hormonal proliferation, especially the IGF. The effect of training intensity, what training intensity do you have to do? How about the actual intake effects? If you take in, what are some of the things we need to look for in the athlete?

A couple of things, creatine will not help if a person does not work at significant intensity. If they are not working 75%, 80%, or 85% of their max, in terms of intensity, it is not going to help anyway. It does not even matter.

Now the actual intake. Some athletes will have GI distress with it. I have worked with some athletes, and some athletes cannot take it unless they mix it in some sort of shake. They might make a shake with some protein in it like bananas or peanut butter ice cream. Something that seems to ease the GI distress.

Before or after, that is another question. It seems to help whether they do it before or after. It is just some athletes handle the creatine better before a workout, some handle it after, and some will try both. Keep in mind when you are putting creatine monohydrate, most of the supplements are somewhat volatile. Let us say you mix it into chocolate milk or something and you mix it up and you drink it, if you do not drink the whole thing right away, some of that creatine will come out of the solution and just end up at the bottom. You may not get all the creatine supplementation that you were hoping for.

Creatine and hypertension, this is a side effects seen in a small percentage of the population. It might have to do with the increase in water retention where they will have a hypertensive effect. It is not something that is seen commonly but it is seen in some athletes.

Let us look at the effect of creatine supplementation on explosive performance and optimal individual post-activation potentiation. The two principal mechanisms for the development of fatigue are the rephosphorylation of adenosine diphosphate, and an increase in the concentration of hydrogen or lactic acid. This will start to increase your fatigue. Additionally, creatine supplementation may facilitate the reuptake of calcium into the sarcoplasmic reticulum via calcium pumps. Now we talked about how important it is.

Creatine supplementation can augment the resorption of calcium. There is less soreness in the muscle. We talked about what happens if calcium with fatigue is just hanging out in the myofibril. You activate the calpains, you activate some contractile hyperactivity, and this is where some of the soreness occurs. What they demonstrate in this study was that creatine supplementation improved maximal muscle strength and optimal individual post-activation potentiation time for complex training, but it had no effect on explosive performance.

They were not getting strength changes but, in the squat, you can see the improvement, but it did not seem to transfer over to the vertical jump. This might mean that you must be more specific in the type of activities you are doing when you are using the creatine if you want to get the benefits of it.

I am just going to go back here for a second. I realized one of the things we did not talk about was the actual dosage. I just mentioned it briefly. But if you look at some of Hultman's original studies, most of the creatine original studies which showed benefits were based on percent body weight. For example, if you wanted to load the body with creatine, if you felt there was efficiency, it would be 0.3 grams per kilogram of body weight. In a 70-kilogram athlete, you are talking about 20 to 25 grams of creatine to load. But if you are talking about your daily intake, it was 0.03 grams per kilogram of body weight.

Basically, maybe three grams of creatine every day just to help maintain the creatine you have. At this point, most people feel you do not really need to load the body. If you just take a normal amount of creatine every day, you will get the benefits. I would recommend if you were just taking three to five grams per day in a shake, this would give you the benefit of the creatine and help with recovery.

There have been some studies, that have said that creatine might help in terms of brain function and cognitive function especially as we get older when we start going into our 50s and 60s, that the creatine, because of the energy and supplies, might help with cognitive function. They did some animal studies that showed if the animal, the rat studies if they were on creatine and then had a concussive force applied, they did not suffer from concussions as much if they had creatine in their system. This might all be because it probably delays the cascade effect that leads to a lack of energy for the brain. Remember, the brain does require primarily glucose to function.

If we look at cellular oxidation, we are talking about the removal of electrons from hydrogen which is oxidation and passed to oxygen, we are talking about biological burning and oxygen is the final acceptor. If you wonder why we need oxygen, it is to accept the electrons so we can just have enough energy. There are some organisms where nitrogen is the final acceptor. These are few and far between, usually, they are deep under the ocean or possibly in outer space. We use oxygen and that is how we accept the electrons now. You will find out when we do not have enough oxygen you will see what happens, we produce lactic acid.

Here is our electron transport system. This is catalyzed by the dehydrogenase enzyme. You can see nicotinamide, adenine, dinucleotide, and flavin adenine dinucleotide. These are the B vitamins that we need which help us with the electronic transport system. So, yes, if there is a deficiency in these vitamins, then there would be a deficiency in the energy systems and what we can get out of the metabolic pathways. Oxidative phosphorylation is the transfer of electrons from NADH2 and FADH2 to oxygen. When we look at energy production like if we look at glycolysis and immediate, that is taking place in the cell but outside the mitochondria.

When we look at glycolysis in terms of respiration and oxidative phosphorylation, that is going to take place within the mitochondria. Some of the adaptations are the enzymes needed for these reactions where they increase with strength and conditioning, and we will see that as we get into the cell membrane because we will talk about beta-oxidation and fatty acids, which fatty acids can get in, which fatty acids cannot get in.

Cellular oxidation. Exercise and oxidative stress. If you exercise, you are creating oxidative stress. Our reactive oxygen species are going to be created. This is when we start talking about free radicals. This is performed from an imprecise coupling. Oxygen is very volatile. During the reduction of oxygen to water in the final stage of electron transport, free radicals will be formed. Now, this will react with the cell membrane, and it can create changes in the cell membrane and let things in. This is where if you have enough free radicals, instead of being part of the normal process, the normal balance, and homeostasis of the cell, can lead to damage. It can lead to DNA damage in the long run. But in general, oxidative stress is a normal part of the exercise, it is a normal part of living. Five percent of the oxygen used during exercise will create free radicals. This is not a problem. In fact, this increase in free radicals will lead to an increase in the antioxidants that we need for normal functioning and for improved performance.

Here are the three primary antioxidants. Keep in mind these are inherent in our bodies. You do not really need to supplement them. Probably, the best way of supplementing them is just to exercise more. We have superoxide dismutase (SOD), we have catalase, and we have glutathione peroxidase. One of the things you will notice is under each one of these, I listed certain minerals because these are the cofactors. If you do not have these cofactors, the antioxidant will not work properly if at all.

In the cytoplasm, you can see superoxide dismutase needs copper and zinc. In the mitochondria in the muscle in myocardial tissue, it needs manganese. Now, catalase needs manganese and iron. Glutathione peroxidase needs selenium. The reason why I mentioned these minerals is because you can have athletes who have very good diets with lots of fruits and vegetables but if they do not know where their fruits and vegetables are grown, it is possible they are mineral deficient. Even if they think they have a healthy diet, they could be mineral deficient. When you talk about supplements, if we must take them, we talked about creatine monohydrate as a supplement, how about minerals and multi mineral as a supplement might be even more beneficial for the normal performance and improve performance of the athlete. Now interesting enough, catalase also requires iron, so we must be a little bit more conscientious when we talk about our female athletes who sometimes tend to be iron deficient. Once again, therefore I propose that supplementing minerals can be an excellent idea.

Now, superoxide dismutase triggers the dismutation of oxygen to hydrogen peroxide and oxygen. Dismutation, all that means is oxidation and reduction are occurring at the same time. That is because of the volatility of oxygen. Catalase converts peroxide to water and oxygen, and then the glutathione peroxidase uses reduced glutathione to reduce the hydrogen peroxide to oxidize glutathione and water. This is what it looks like. This is the enzymatic pathway for detoxification of the reactive oxygen species. Remember, reactive oxygen species, these free radicals also trigger inflammation in a healthy manner when we talk about neutrophil activation and monocyte activation.

Reactive oxygen species act as a signal to the muscle as part of the adaptation of the muscle. Exercise is an antioxidant. What factors appear to have the most antioxidant activity? Well, in terms of vitamins, vitamin C has high antioxidant activity. In fact, there were studies a while ago with HIV patients where massive doses of vitamin C were very beneficial. Vitamin C works but too much vitamin C and now you run into the problem possibly of dehydration. If you were not doing a lot of vitamin C, please make sure you are hydrating properly.

What is interesting is the number one factor that appears to have the most antioxidant activity is calorie restriction. Just do not eat too much. Eating and the breakdown of the macronutrients really will produce a lot of reactive oxygen species. If you just eat in a healthier manner, you are going to have better antioxidant activity.

The second major factor after calorie restriction for increasing antioxidant activity is exercise. Even though exercise is creating more free radicals and reactive oxygen species, it also triggers the increase in our natural supply of antioxidants.

Let us look at glycolysis or the breakdown of carbohydrates. Fast glycolysis, we need energy quickly. Maybe we use some of our ATP, we are going into high intensity. Not our highest intensity but high-intensity activity, so you need to break down carbohydrates a little quicker and the result is lactic acid which will be converted to lactate in the blood. Now, I want you to keep that in mind, this is not a waste product, this is an intermediate product because the lactate in the blood can then be converted back into ATP and converted back into energy if you start to get oxygen back into the system. This is occurring in the cell, but it is not occurring in the mitochondria. It is not as efficient in terms of producing energy, but it is a much quicker way of producing energy.

Then we have slow glycolysis, where the pyruvate that is broken down is now transported across the membrane into the mitochondria. This becomes the electron transport system. Glycolysis is controlled by the rate-limiting step of conversion of fructose-6-phosphate to fructose-1, 6-biphosphate, which is catalyzed by phosphofructokinase. That is a lot of syllables. What does that mean? Well, you will find this enzyme in the liver. You can break down glucose and get it into the bloodstream very quickly. We really do not have this in the muscle so once the glycogen gets into the muscle, it really cannot be transported to other muscles as far as we know.

The energy from the nutrient breakdown. Carbohydrates. Carbohydrates are our only anaerobic energy source. The brain needs carbohydrates and glucose. Glycogenolysis is where you break down the glucose molecule. Glycolysis is the first stage of glucose degradation, consider that maybe fast glycolysis. Then the pyruvate enters the membrane and goes into the citric acid cycle. This is where we release the remaining energy from the glucose.

With carbohydrates, some people say, "Well, let me get more carbohydrates into my system." We talked about the concept of carbohydrate loading. First, let us talk about the classical loading procedures. Let us first describe why you must go into a depletion stage first. Let us say you have a race in seven days. On the first day of that week, exhausting exercise, 80-90% of the VO2max. You are trying to get rid of all your carbohydrates.

Remember you must go intense otherwise you will burn fats and you will not be getting rid of all your carbohydrates. Day 2 to 4, you have a low carbohydrate intake, so you really do not let the body resupply itself. Then you get into the carbohydrate loading stage, Days 5 and 6, with high carbohydrate intake, 2 to 3 sessions of very low-intensity exercise. Then competition day, this is where you get that super-compensation.

In the previous session, session one of exercise physiology, we talked about the only place we really have seen super compensation take place on a physiological level has been with glycogen. This is the procedure. This is a tough thing to do though if you are doing classical loading procedures, let me tell you, you are going to be very cranky, you are going to be very stiff, and you are going to be very sore these first couple of days.

A lot of people do not do it, I am not sure it is worth it. Unless maybe you are at that elite level. I would suggest to you that if you are going to try this, obviously, you try it in the practice, and you would never try this for a race when you have not used it before. We know how disastrous it is to try something new for competition. But you can do a modified loading procedure. Your basic modified loading procedure is where you really eliminate the exhausting exercise.

You just do some moderate exercise which obviously does not burn as much glycogen or low carbohydrate intake. Then you just try and increase carbohydrates the last couple of days. I think the modified loading procedure becomes more of social activity. This is the classic old pasta dinner the night before the race. I think that is almost more of a social activity now at this point than it is an actual physiological benefit.

The other thing is if you do the classical loading procedure. These last couple of days when you get super compensation if you are going to increase glycogen to that extent, you are also going to increase the water uptake. You almost might feel a little swollen, a little stiff because you are going to have more water resorption because of this high carbohydrate intake.

Keep in mind a couple of things. Carbohydrate from a bar is effectively oxidized during exercise. Carbohydrate ingestion can be effective with a gel as well as a drink. Although we do not really want to have any carbohydrates just before the race for 15 to 20 minutes because we are worried about insulin spikes, once you are exercising the metabolic pathways are going, then there is no problem in taking carbohydrates during the race. But do you really need them? Well, not if your event is under 60 minutes. You really want to be in that 60 to 120, or even 180 minutes to have any effect from taking the carbohydrates in during this competition.

Now, we are going to look at the macronutrient lipids and the energy that we can get from these lipids. This is almost freeze-dried energy. This is where we get most of our energy. The number of calories we have in our body in terms of fat is about 60 to almost I think 100,000 kilocalories within our body obviously, we cannot use all of this. A lot of this fat would be in the cell membranes, and we do not want to use our cell membranes for energy. Adipogenesis is the maturation of the fat cells. Now, lipolysis provides 30-80% of the body's energy.

It liberates the free fatty acids. This is really where we want to be in terms of creating energy. This is where we can go long-term. This is our endurance. This is the energy that we need. The better trained you are and the increase in lipases that you have so that you can mobilize these free fatty acids a little bit quicker, that will let your spare glycogen. That is the glycogen-sparing effect that we talk about.

Then we want to also talk about - how lipid intake in general, and how much fat should be taken in? Well, there are all many different types of concepts and diets about how much lipid you should take in. Generally, I am going to speak in generalizations because people do not agree with everything but less than 30% of your total calories should be fat. Then you have the ratios, polyunsaturated to saturated fat ratios, 1:1 minimal, 2:1 preferable.

Then if you want to talk about your polyunsaturated to monounsaturated to saturated fat ratios, we are talking about a 1:1:1 if you can do that. Some people obviously will say, "Well, that is too many lipids." Other people will say, "Well, I will take in more. I need to take in more liquid for energy." A lot of it would be your activity level. If you are looking at a cross country skier or a long-distance runner, the number of calories they burn, you will have no accumulation of fat.

When I was in college when I was running track for a while, I was running 70-90 miles a week. The number of calories I was burning really did not matter what I had in my diet as much because it was all being burned anyway. I could easily go 5,000 calories a day and still have trouble maintaining weight. In that sense, the amount of fat I was using was all being used for energy, and none was being used for accumulation. I can never maintain that type of diet these days without ending up with severe coronary artery disease.

When we look at the entire circuit in here. Here, when we break down carbohydrates, you can see this is pyruvate. This is what enters the mitochondria. Then you can also have some protein oxidation, the amino acids which will come in the Tricarboxylic Acid Cycle sometimes also known as the Citric Acid Cycle, then fatty acids. The fatty acids are going to enter the membrane. Now, short-chain and medium-chain fatty acids can enter right into the mitochondria through the membrane. Long-chain fatty acids cannot enter.

They must be transported in. They will be transported in by carnitine. We will talk about that in a little bit also, the benefits of carnitine. But you can see this is where we are going to get most of our energy and the electronic transport chain right through here.

One of the things we have had to deal with is, and this is more with my regular patients than my athletes, they will come in because of some of the social media exercising at a lower percentage of your VO2 max will burn more fat. What that should say is it burns fatter percentagewise.

I did a chart to show you what that exactly means. We look at a 77-kilogram person, 170 pounds. Let us have them do 30 minutes of exercise. If they do a 20-minute mile, that is easy. You can see they are burning 5.7 kilocalories per minute. Under that condition, a lower percentage, yes, is 80% of the energy used is fat use.

Those are the calories you are burning but you are burning 80% of a much lower calorie total, so if you look at total fat calories if you are on a 20-minute mile or 11-minute and 32-second mile, you are burning more calories if you run faster. Yes, you are only burning 50% of your fat but when you are done because your temperature will be up, you will still be breathing, you will continue to burn calories. Overall, you are going to end up burning more fat. This is the ideal situation.

If you are talking about a seven-minute mile and you are doing 30 minutes per session you can see you are burning a lot more per minute, it comes out to about the total fat calories for the exercise session but once again, post-exercise, you are going to end up burning more calories. That because you add a rest period will be more fat calories. I mean, ideally, if you are sitting here just watching this session, the calories you are burning is probably about 95% of fat. Unfortunately, it is 95% of almost no calories expended so it is not very helpful.

We will talk about proteins; this is one of the things which annoy me. I really think that most people, or athletes get enough protein. I mean, the question we asked is “do athletes need more protein? Does excess protein stimulate strength and development? Do supplemental protein powders work? Does excess protein intake have medical risks?”

When we look at the breakdown of protein, the metabolism of protein requires the deamination process before it can enter the pathway for energy release. This is where for a while, people were advocating high protein diets for weight loss because of the number of calories you would burn just breaking down the proteins. But that still does not take the place if you are just using the diet, it is not going to be very beneficial.

In the United States, the RDA is 0.8 grams per kilogram of body weight. That is the recommended daily allowance. They say that 1.5 grams per kilogram of body weight would be considered a high protein diet. I mean, we will look at these numbers but let me just say, this is ridiculous, so let us look at some of the evidence that supports it.

Here are some of the recommendations. I already talked about the USA-RDA recommended daily allowance. The American College of Sports Medicine, for endurance and strength they are recommending at least 1.2 to 1.7 grams per kilogram of body weight. This is for endurance, too. I don't think most people realize even though you are not getting a lot of hypertrophy with muscles, there is still a high protein turnover in the muscles when you are doing a lot of endurance exercise.

Drogon was a Bulgarian strength coach, and he was looking at 3.5-4 grams per kilogram of body weight. He was working with weightlifters which is a different population but that is a lot of protein. If you consider that maybe a 5–6-ounce steak might have 80 grams of protein, well, let us figure it out. Let us say you have about a 90-kilogram lifter.

If you are looking at 4 grams, that is 360 grams of protein that you would need for that lifter. If they had an 8-ounce steak, maybe you are looking at 100 grams. You are looking at maybe 4 steaks a day for 8-ounce steaks a day, that is a lot of meat to take in.

Luke Bucci had an interesting text on injuries and rehab. His recommendation based on the evidence, he was looking at is that if you are recovering from an injury or rehabbing from an injury, you would want at least 2 grams per kilogram of body weight to help you during that recovery and rehabilitation process.

This was an interesting study by Luetkemeier and Bradburn. This was a four-week study. Twenty-three college seniors who lifted weights three times a week - these were not beginners; these were seniors who had lifted for a while. They gave them different protein levels. The levels were either 0.4, 0.8, 1.2, or 1.6 grams per kilogram of body weight. The seniors at 1.2 gram, remember that is the lower level of what the ACSM recommendation was, had a negative nitrogen balance. If you have a negative nitrogen balance, you are not going to build muscle.

In fact, you might even lose some muscle mass. Seniors at 1.6 grams barely maintained a positive nitrogen balance, so, 1.6 grams did make it so especially if you were trying to maintain weight, that would be good. I think at least looking at this evidence, this is where you start thinking about 1.5 to 2 grams per kilogram of body weight seems to be a pretty accurate recommendation.

Protein requirements are elevated in endurance athletes after exercise. They reported that after their studies, they recommend a protein intake for endurance athletes of 1.65 to 1.83 grams per protein. Once again, much greater than the RDA. If you look at the current recommendation for endurance athletes as reported by the ACSM, also 1.2 to 1.4. Once again, I think we must look at and discuss the concept of protein intake and an increased protein intake for athletes who are not getting enough.

The energy from nutrient breakdown. Whey protein is a protein supplement. It is something I use, too, I try and avoid red meats. I will have some, but I try and avoid them. I will get my protein from a plant-based diet, but I also am taking in chicken and turkey and fish. But you can see the different types of supplements you have. The concentrates of whey protein, low levels of fat and cholesterol, and high levels of bioactive compounds. The isolates were processed to remove lactose and fat, slightly lower in bioactive compounds but if you are lactose intolerant, this would be a good supplement to use. The hydrolysates pre-digested and partially hydrolyzed more easily absorbed, and most effective, but they are also more expensive.

If you try this, when you mix it in with liquid it has a bit of a chalky taste. Most of the supplements that you are going to buy in the market are a combination of concentrates and isolates. This seems to work best for me at least. Once again, you are always talking about how people will react, it is an individual thing but there are some generalizations we can make. But I think this is a wonderful way of getting some protein supplementation.

One of the things we have seen is carbohydrate and protein ingestion after a workout. This is the ratio that they found: 1.06 grams of carbohydrate to 0.41 grams of protein per kilogram of body weight, 0 to 2 hours post-exercise, this increases plasma insulin and appears to increase growth hormone. If you have this combination after a workout within that two-hour window, you may improve the benefits of your strength training.

Interestingly enough, this ratio is what you will often find in chocolate milk. How many people can drink chocolate milk after a workout? Not a lot of people can do that. I can, I love it and sometimes I will have the chocolate milk and then I will put in my protein powder with that. I also may add my creatine at that point. It will be an all-encompassing shake for me.

This was an interesting study: Resistance Exercise Augments Postprandial Overnight Muscle Protein Synthesis Rates. Is there a way of increasing your protein synthesis while you are sleeping? Here is what they did, they used an exercise protocol, which consisted of 60 minutes of lower body resistance exercise. A lot of leg extensions, leg presses, and leg curls. They completed the exercise two and a half hours before the person was going to sleep. At the end of the exercise, they gave them 20 grams of protein but just before sleep, they gave him 30 grams of protein.

They measured protein synthesis rates that were increased in that 30-40% range so they did get a very good increase. Now, you always talk when you look at the research, look at the evidence, how feasible is this? It is for someone who does not mind exercising later in the evening.

This would not be a problem for me. Exercising early in the morning is more of a problem. If you get athletes to do this and some competitive athletes especially younger athletes will do this, but it is also a question of, two and a half hours before sleep, what is your fatigue factor at that point in the day?

I thought this was an interesting one to also add: Leucine supplementation enhances integrative myofibrillar protein synthesis in free-living older men consuming lower- and higher-protein diets. The intake of protein and the ability to absorb protein is not equal across the board. As we get older, we lose some of our ability to absorb and use protein. If anything, we need a higher protein intake. They found that when they did the supplementation of leucine, which is a branched-chain amino acid, and they mix it with regular meals they actually had an increase in myofibrillar protein synthesis. When they say free-living older men, we are talking about 70-year-old men who are living on their own as opposed to being in a nursing home. I mean, that is an entirely different subject that needs to be addressed but if you consumed high protein, you had an improvement in your resistance exercise and your strength.

Leucine co-ingestion with daily meals enhances integrated myofibrillar protein synthesis in rested and in training conditions. It was equally effective in all men who consumed daily protein and takes greater than or equal to the RDA. Even if they were taking the accepted protein intake, this still helped absorb and helped use the protein in a greater fashion.

When we go back to these questions, "Do athletes need more protein?" Everyone needs protein, especially your athletes. That is something you should consider if they want to get the greatest benefit out of their conditioning. "Does excess protein stimulate strength and development?" Not unless you are working out. I mean, you cannot just take increased protein and think it will help although, there are some people who may not be getting enough protein for their normal daily intake. If they are just getting maybe a gram of protein per kilogram of body weight? No. I would say that the excess protein might stimulate strength only in terms of performing their activities of daily living.

"Do supplemental protein powders work?" Absolutely. They absolutely work then it becomes a question of price. You would rather get it from food, but a lot of the foods are going to be high in protein. Unless you are talking about a plant-based diet. If you are talking about fish, and you are talking about some of the meats. Yes, that could get a little expensive.

I think one of the things you must look at with some of the younger athletes that I was working with is they will have these protein shakes and they will be quite filling, and they need to be supplemental, and they will almost use it in place of a meal instead which is not what you want. If they are getting breakfast, lunch, and dinner, the idea is not to have a protein shake at lunch which will eliminate the protein that you would normally get from your lunch.

Where the supplemental protein powders work especially with my younger athletes is before bedtime. I know some athletes who are a little bit more extreme in their approach, they will get up at 3:00 or 4:00

in the morning and have a protein shake and go back to bed so they can get that increase in protein. That has provided some benefits.

The next question is, "Does excess protein intake have medical risks?" The medical risks that have been associated with excess protein, I think when I am looking at the evidence seems to be more dietary in nature, that people who are getting two and a half three grams and tend to be centred, they are getting it from a lot of red meat which I think is more of the issue. I think if you are in those two grams per kilogram of body weight, I have not seen anything that suggests that you are going to have any medical risks. So, yes, if not getting extreme, the people who have more medical risks are usually sedentary people whose diet is just too high in processed foods and red meat.

We are going to start taking a look at aerobic and anaerobic exercise, and some of the differences in conditioning. Aerobic exercise is brisk exercise that promotes the circulation of oxygen through the blood and is associated with an increased rate of breathing, running, swimming, and bicycling.

There are so many things you can do cross country, skiing, rowing, and kayaking. Anaerobic exercise is exercise intense enough to cause lactic acid to form. It should be anaerobic exercise is exercise intense enough to cause an increase in the formation of lactic acid because, in fact, even as we sit here, we are producing lactic acid but we are taking in enough oxygen where we are able to metabolize that lactic acid so we do not get an increase of lactate in the blood.

Our oxidative system. What are our substrates? That is one of the things we are looking at. It is all of them. It is the carbohydrates, it is the lipids, and it is the proteins. But what do we want to do primarily? Lipids. Then we want to get most of our energy for the oxidative system, the aerobic system, through the citric acid cycle also known as the tricarboxylic acid cycle.

When we look at substrate relationships, we can see immediate energy, we want ATP phosphocreatine stores as the stored phosphagens. Our glycolysis system will be glycogen and glucose. Aerobic metabolism — glycogen and glucose, fats, and proteins.

The greatest rate of energy production. All right, the fastest you can get it is through ATP and creatine phosphate. Then fast glycolysis, slow glycolysis, and carbohydrate oxidation. Then kicking in with fat and protein oxidation. Remember, it is primarily fat. If you want to talk about the total amount of ATP production, well, then we reverse that order because we did not get most. The greatest amount of ATP production is from fat and some protein carbohydrates, and then the glycolytic system, and the ATP phosphocreatine system.

The effective event duration. If you are looking for very short period, 0 to 6 seconds of very intense energy, all phosphagen. Then you will start kicking the creatine phosphate in about six seconds, six to thirty seconds is intense. That is phosphagen, ATP phosphocreatine, and fast glycolysis. Thirty seconds to two minutes, heavy, fast glycolysis. Two to three minutes, moderate, which is fast glycolysis and start oxidation to kick in. Greater than three minutes is considered more of light intensity. That is where we talk about just oxidative phosphorylation or oxidation.

This is out of the book on exercise physiology from McArdle, Katch, and Katch. One of the things you will notice is it is not that one is on and then the others are off. It is almost like dimmer switches where if you turn it on just a few seconds, yes, it is primarily ATP but the other systems are already kicking in. Remember, when we talked about ATP, how it is broken down, and the adenylate kinase reaction, which will give you an ATP and an AMP, which is a cyclic messenger.

Well, here is the messenger triggering everything right away. Even when you talk about aerobic metabolism, there is still some ATP and phosphocreatine being used from that system as you increase in time.

Substrate depletion and repletion. These are going to be general levels. ATP doesn't usually decrease greater than 6% from its base level. It does not have to because you are going to get feedback right away and start creating these feedback loops to the body to increase glycogen breakdown. Complete ATP resynthesis in 3 to 5 minutes, once again, this is the same rest period we need for power and strength conditioning.

The reason why is we get ATP resynthesis so when you do your next set of one to two repetitions, you will not be involved in the metabolic system, you will just be talking about stimulation of the muscle structure. Complete glycogen resynthesis in about 8 minutes and then if you want to get glycogen repletion say after a game, 0.7 to 3 grams per kilogram of body weight every 2 hours. This is what is going to help you get your full glycogen repletion.

Keep in mind, for someone who is untrained or if it is an extreme event, you are not going to get complete glycogen resynthesis in eight minutes. This is for like a set of exercises or something like that. If you are talking about an event or a game, it could take 24 hours and maybe 48 hours before you get full glycogen repletion.

Once again, our immediate energy system, the ATP-PCr system. What this will tell you, by the way, is like in a 100-meter race, a lot of times, we have talked about it is not the one who is running fastest at the end, it is the one who slows down the least because you are going to get your top max speed. Most people are maxing out at 60 to 80 meters - that is a 6 to 8-second range, then it is a question of, "Can they decrease the rate of deceleration to actually hold on?" If you see someone kicking the last 20 meters, it is just a relative perception that they are slowing down less than the other runners around them.

When we talk about short-term energy, we talk about glycolysis which is in that 60 to180-second range. Maybe even fast glycolysis will be in that 30 to 45-second range. There are two terms that are sometimes used interchangeably, and they are not. One is the blood lactate threshold, and this is the threshold at the point at which during exercise, lactate starts to build up in the bloodstream higher than your resting value.

Usually, a lactate threshold gives you a good predictor of submaximal fitness. The onset of blood lactate accumulation is a little bit different. This is the point where lactate accumulates, and you are looking at its highest level. It almost forces your exercise intensity to decrease. This implies maximum exercise intensity that a person can sustain.

If we look, for example, the blue rating here is the untrained person, and red is the trained person. If you look, this is our resting lactate production. Millimoles per litre of blood are just under two in most cases. As you start to increase your running speed, at a certain point, it is not aerobic. You are going to have to start using a little bit more glycolysis and that becomes your lactate threshold. In this case, your lactate threshold in the untrained person is about 10 kilometres per hour. If you start training, you are going up to almost 12 kilometres per hour. That gives you an idea of your lactate threshold.

You are going to keep increasing your build-up. There is a certain point, the onset of blood lactate accumulation where it could be here, it could be here where your ability to maintain your size, intensity, and start levels off or decreases, that is where we consider the onset of blood lactate accumulation because it is decreasing your ability to perform. You can look at some of these values. You are talking about in the untrained person, maybe 9 millimoles per litre.

The trained person, they are going up to 10. But they have done studies, especially on hockey players. Some of these shifts, these 30-40 second shifts, where I have seen levels as high as maybe 18 to 20. Their onset of blood lactate accumulation might be lower. They get up to a blood lactate reading of 20 millimoles but the onset of blood lactate accumulation, where they can skate at that high intensity and that high speed might be at 15 or 16.

When we look at the onset of blood lactate accumulation, what can we do about this? Is there anything we can do? Any supplements that we might be able to take which will allow us to perform at higher levels so that we do not build up lactate as quickly? One of the things we have seen as a possible supplement is sodium bicarbonate used for athletic performance. This is a nice meta-analysis from 2012.

I became familiar with sodium bicarbonate. Some of the studies at the University of Pittsburgh in the early 80s and were getting some good results but at that time, one of the things they found is they were putting runners on treadmills, and they were getting better performance except for the fact that sodium bicarbonate made them nauseous. They were all vomiting on the treadmill. That is where the work started. Obviously, we have come a long way since then.

One of the things we saw in this meta-analysis when they looked at these different studies is sodium bicarbonate has an overall moderate effect size. In some of these studies, it was not statistically significant but there was a moderate effect size. It appeared to be more effective in recreationally trained athletes. It did not help as much in the elite athletes in terms of values but one of the things is the effect size and elite athletes do not have to be very great. Although only minor benefits were seen in these trained individuals, this can be significant at an elite level. Remember, you have athletes in the 100 meter who trained for years to drop, maybe three-tenths of a second or like three-hundredths of a second even. Even though it is not statistically significant, can still have a major difference.

One of the things they looked at is recommended starting dose - 0.2 to 0.4 grams per kilogram of body weight, 60 to 120 minutes pre-exercise in flavored water or capsules. A couple of important points here. Some of the original studies I have seen. This fits in very well that 0.2 to 0.4 grams in a lot of studies. Sixty to 120 minutes pre-exercise, I would suggest to you that even a little bit earlier, more like 120 to 180 minutes pre-exercise, I think athletes from what I have seen, anecdotally handle that a little bit better.

If we are talking about supplements, how about the effects of combined creatine and sodium bicarbonate supplementation on repeated sprint performance? Get the creatine for recovery but the sodium bicarbonate so you can perform at a higher level.

Thirteen male participants, VO2 max greater than 55. We are going to talk about that but that is a nice aerobic intensity. These were male participants with greater than five hours per week of aerobic exercise, high intensity greater than two hours a week. This was not your basic untrained person or just a simple recreational athlete.

These were trained athletes. They use supplements of creatine and sodium bicarbonate, 20 grams of creatine which is almost a loading dose, and 0.5 grams per kilogram of body weight. At the higher end of what allowed the evidence says but still within the normal amounts of most of the evidence.

Two days of supplementation before the test but no supplement the day of the test which gets rid of the possibility of nausea from the sodium bicarbonate in the athlete. The test was 6 by 10 second Wingate sprints. If you are not familiar with a Wingate sprint, a Wingate sprint sometimes is 30 seconds long, but it is a bicycle ergometer and you are pedalling as hard as you can. A very tough thing to do. If you have ever had to do a Wingate sprint, 10 seconds is an eternity, and 20 to 30 seconds is pure hell.

A 60-second active recovery was performed between sprints. Based on the supplementation for the previous two days, there was a significant increase in peak and mean power and less of a decline in relative peak power over the six sprints in the combined supplementation condition. By using the supplements, you can work at a higher intensity which obviously is going to help with training and help with performance.

One of the things it is doing is that sodium bicarbonate is influencing the pH. This is an interesting thing. If we look at a normal blood pH value of 7.35 to 7.45, maybe you want to talk about an average of 7.4. When we are talking about athletes who are training hard, especially in the anaerobic state, they will get their pH down. They will get down to 7.0 blood which if you walked into a hospital emergency room with a pH of 7.0 in your blood, they would consider an emergency, put you on oxygen or everything like that but an athlete can compete and get to that level.

Although there will be side effects. If you are trying to train, if you are doing repeat intervals, high and anaerobic intervals, and your blood pH is 7.0 - 7.1, you are probably going to get some nausea. You are probably going to have some headaches. But what we read in the blood is not the same as what we are going to see in some of the cells and tissue.

If we look at the pH in some of the muscles compared to the blood, a pH of 6.6 can be attained. We are starting to talk about changes in the viscosity of the connective tissue, Hyaluronic acid which is an important part of the extracellular matrix and connective tissue, if you are working anaerobically and it is 7.0 - 7.1 in the blood, well, you might be at 6.6 within the muscle cell and within the connective tissue. This is where you are starting to get that stiffness in there.

There is an old term I do not know if they are still using it, we used it in track and field where you are in such bad shape. You were "rigging" which was short for rigor mortis because that is what it looked like. That may lead to additional stiffness seen in athletes after prolonged activity. This can be heightened or exacerbated by being in a state of dehydration. Once again, if you are talking about the extracellular matrix of the connective tissue, hydration is a very important factor.

If we look at oxygen uptake, and we look at aerobic exercise, some of the terms I want you to know — maximum VO2. The amount of VO2 you can use, and this are measured in millilitres per kilogram per minute. Then we are going to talk about oxygen deficit, oxygen debt, and excess post-exercise consumption (EPOC). Maximum VO2 is the point at which oxygen consumption plateaus and shows no further increase in your workload.

You are sitting here right now, and then I asked you to get up and you start getting up and you start doing a steady state exercise. You start gradually increasing the intensity, and as you increase the intensity, you increase your oxygen consumption. There is going to become a point where you will start to keep increasing the intensity, but you cannot take in any more oxygen, and you plateau there. That is your maximum VO2. If you keep exercising, increasing your activity, and your intensity, now you are going to start getting into your glycolysis. It is your anaerobic state.

What are some good max VO2 values? Here are some of the top values for men and you can note the different sports: Oskar Svendsen cycling, cross-country skiing, and cycling. Look at the Max VO2 on these milliliters per minute per kilogram. This is high. I would suggest to you based on what I have read, that a lot of the evidence is if you are an elite endurance athlete, you are going to be in that 70 to 90 milliliters per minute per kilogram. That does not mean you get a win do not equate maximum VO2 with performance because you can have an elite athlete who might be at 80, who still might be the one who is winning.

But this is in terms of just your maximum aerobic capacity, of course, there are other factors involved in performance besides just maximum VO2.

Here are some of the values for women, running cycling, cross country skiing. One of the things that you will notice is that at least just in terms of max VO2 that the top women really enter into the realm of elite performance in male competitors because as I mentioned before, in the male competitors, the elite level is in that 70 to 90 plus max VO2 while your top women are still in that range. In that bottom range. They would all qualify as elite when compared to the male participants.

Your oxygen deficit. This is a difference between the total oxygen consumed and the total oxygen that should have been consumed had you reached a steady state of aerobic metabolism at the start of the exercise. That is oxygen deficit. This will make a little more sense in a minute or two.

Your oxygen debt is the oxygen consumed during recovery that exceeds the amount of oxygen that would be consumed at resting levels. Also known as excess post-exercise oxygen consumption (EPOC). Here is what it looks like. You are sitting, you are resting, and you get up to start running. Well, most of you know that your body does not kick in right away, the aerobic metabolism so you are going to supplement this part under the line.

We go right into a steady state. There will be some anaerobic energy process going on here. You are going to have to make this up. This is the oxygen deficit. Now, when you stop your exercise and you just sit, you will notice you are still breathing hard. Your blood is still pumping a little bit, your heart rate is still elevated. That is because you still going to be taking in oxygen in here, that is your debt. You should think of this, like when you check into a hotel and you give them your credit card, well, that is a deficit. At the end of the month, the bill comes in, you got to pay that off. That is your oxygen debt. That is what you have to pay off.

The excess, the oxygen you take in this excess post-exercise oxygen consumption, is what we are talking about. This is how you pay your oxygen debt. This will be different. If you are trained, you are going to get down and you are going to get down very quickly because if you are a trained person, you will get to that steady state much quicker, and you will have less of a deficit so then you will have less of a debt.

But if you are training very hard, even if you are a trained person, let us say you are training for 45 minutes at 75 to 85% of your maximum intensity, when you stop, that will keep going and there will be a 24-hour period where you are going to burn more calories.

This excess post-exercise oxygen consumption can stay at an elevated rate for at least a 24-hour period where you can burn. These are some of the studies they have done where you can burn up to anywhere between 20 and 40% greater calories than would be expected from the exercise just performed. This concept of excess post-exercise oxygen consumption is the basic theory behind the fitness chain, Orangetheory Fitness. Or I think that is Orangetheory Fitness or Orange Fitness Theory. I forget, I am not even sure what they do but I know it is a global chain. That is the whole concept where you are going to train at such a high level that when you are done, that metabolism is going to go at an increased rate for the next 24 hours and there is a lot of evidence that backs this up.

We will talk about some of the cardiovascular anatomies at this point. We want to look at cardiovascular anatomy and physiology and how this plays a part in training, especially for the athlete. This is just a quick review. You have the structural anatomy, and then you have the conduction, the ECG, the P wave, atrial contractions, QRS complex, ventricular contractions, the T wave, and ventricular repolarization.

That is just a quick review. Just keep in mind when we talk about measuring heart rate and heart rate variants, we are going to talk about different intervals. You can measure R to R, or S to S. It is your choice.

Some of the cardiovascular responses to exercise. We talked about cardiac output, which is your stroke volume times your heart rate. The stroke volume is going to be regulated by end-diastolic volume and sympathetic hormones. You will see the difference, for example, in swimmers because when a swimmer's end-diastolic volume fills up easier than if you are running upright. Because in swimming, you are horizontal so the circulatory system isn't fighting gravity, so it is easier to fill up in diastolic volume, so you will get the same cardiac output, but your heart rate may not go up as high as your maximum heart rate.

You will see this a lot more in recreational athletes as opposed to your elite athletes. Blood pressure obviously goes up. Systolic blood pressure is going up with your response to exercise and then the oxygen extraction going to get more oxygen out of the blood. How much oxygen do you get out of the blood? Well, once again it will be based on your training because you will start an increase in enzymes which will allow you to take more oxygen out of the blood as you train.

Your cardiac output, heart rate times stroke volume. Heart rate, and stroke volume, are all simple definitions. Stroke volume is the amount of blood pumped out of the left ventricle in each cardiac cycle.

Let us look at two different people. The first person here, 70 beats per minute is the untrained person, and the 50 beats per minute are your athlete. Well, what will happen is and this is at rest. The untrained person, they have a normal stroke volume is 70 millilitres. But your trained athlete, your trained cardio athlete, this stroke volume, remember the heart is a muscle and that is what they are training. Their stroke volume is much stronger and much more efficient, a hundred millilitres per beat. If you look at 70 times 70, so your untrained person at rest is getting almost five litres per minute, five litres of blood per minute circulating. Your trained person, even though it is only 50 beats per minute is still getting that same five litres per minute but that is at rest.

Let us see what happens when we look at exercise now. First, the untrained person then the trained person. Well, one of the things we know is that the untrained person can still get their heart rate up just as high as a trained person, but they cannot increase their stroke volume as much. In the untrained person, maybe with an increase in intensity in exercise, they will get up to 100 millilitres per beat. But the trained person can get up to 160 millilitres per beat. Now, look at the difference in cardiac output during activity - 20 litres versus 32 litres, that is a lot more oxygen. That is a lot more blood being pumped and a lot more oxygen being carried to the muscles in the trained person.

When we look at the distribution of cardiac output during rest, we can see there is going to be a difference. At rest, muscles get 20% but in exercise, 84% of the cardiac output is going to the muscles. The heart gets its share no matter what. I feel like the heart is like a bookie taking bets. The heart is going to get a share no matter what you are doing. You can see through the shunting of the blood to the muscles from the organ. Both the liver and the kidney, all of this decrease.

There is also some decrease in the blood to the brain. Sometimes I think about, as a fan of sports, you are watching near the end of the game and you say, "Oh, I cannot believe what a boneheaded play. How can he do that?" I think of the athlete though who you take a combination - there is some decreased blood flow to the brain, and he now combines fatigue with it. If they are not in the best shape, there also might be a decrease in circulating glucose because of their fatigue and deconditioned state.

It becomes much more understandable how someone can make a mistake which to the untrained person sitting in an easy chair at home watching a big screen TV seems inexcusable.

You have the oxygen exchange in the blood, that is what you need. The purpose of the circulatory system is to get oxygen to the muscle. Why do we need oxygen in the muscle? Because it is the final acceptor for the electron transport chain.

Once again, that is how we are going to end up getting our energy. Some of the potential limiting factors: it could be at respiration, it could be at lung ventilation, it could be not enough mobility through the ribs and thoracic spine but respiration general, central circulation, your cardiac output, your blood pressure, hemoglobin concentration, then your peripheral circulation, your ability to shunt blood to the muscles, your capillary density, your ability to extract oxygen from the blood.

But this all can be trained. You are going to increase your peripheral circulation. All this will be part of your training adaptations towards aerobic exercise. Then the muscle metabolism itself. Your enzyme potential, your substrate availability, mitochondrial muscle mass, and type.

Interestingly enough, with exercise, aerobic exercise, and cardio exercise, you will get an increase in the number of mitochondria. You will also see some translocation of mitochondria, where the mitochondria will get closer to the cell membrane so you can get the energy out quicker. You can get an increase in mitochondrial number and an increase in mitochondrial density in certain parts of the cell.

When we are talking about getting benefits from cardio exercise, we talked about the training sensitive zone. To try and figure out the training-sensitive zone, we have an equation. We start with the maximum predicted heart rate, which is 220 minus your age. Then you look at 70 to 90% of the maximum heart rate for fitness. That is your fitness level.

If you are talking about really training for performance and exercise, now you are talking about 85 to 90, 95% of your maximum heart rate, even going up to 100%. But for fitness 70, 90%. Swimming is only 208 minus your age. It is for the reason I talked about before is because the end-diastolic volume is easier to get to in the horizontal position.

This heart rate max came from a fax out of Ohio State University, and this came in 1971. One of the things we have seen with this equation is it can significantly overestimate the heart rate maximum in younger adults and underestimate the value in older adults. This is the predicted maximum heart rate that the American Heart Association is still using. This is Gelish.

A lot of people have been using different equations trying to make it a little more accurate. What I used is for a 60-year-old person, if they were using the standard predicted maximum heart rate, they would use 160. Now with these equations, you can see you would have a slightly higher rate for the older adult, 165 and 166. These are not huge changes in terms of significance. If you talk about 90% of 160, that would be about 144. Here, maybe it would be 145 or 146. Even with all these differences, if you want to get highly technical with the equations, they do not really change that much.

We are going to look at using the standard heart rate evaluation. Let us look at the 30-year-old athlete versus the 50-year-old athlete. Remember 70-90% of your heart rate. If you look at the 30-year-old person, 220 minus their heart rate. This is the predicted maximum heart rate of 190. Their target heart range is going to be 133 to 171. Whereas the 50-year-old, it will be 119 to 153. But I will tell you for a lot of 50-year-olds if they are in shape, this is too low.

This will not be enough to really get that really good performance for the training sessions. It might be enough for fitness but 153 really would almost be like 70 or 80% of what their zone should be. You can see this is where the underestimation takes place. Ninety percent for 30-year-olds in shape 171, even that is going to be a little light in terms of your standard training session.

What we want to do to make up for this is use the Karvonen method. The Karvonen method takes into account that you are in good shape, you have a higher heart rate reserve, and a lower resting heart rate. Now what you do is figure out what your training is going to be, you take your heart rate at rest, plus your training interval. In this case, we are going to use 70%, we are going to use the lower value of the training fitness.

Your heart rate max is still the same, 220 minus your age, so it is still going to be 190. Here, you are going to take your heart rate max minus your heart rate at rest, so it is 190 minus 60, so you have 130. You take 60, your heart rate at rest, plus 0.7 times the 130. You end up with a target heart rate of 151 for your 70% training zone.

Let us review the Karvonen method for this 30-year-old athlete who is in good shape. If we just use that general estimation, we can see that the target heart rate would be 133 to 171. At 133, you are not going to get much benefit. But if you consider that they are in shape with their resting heart rate and their heart rate reserve, using the Karvonen formula, their target heart rate is now 151 to 177. You get a much more accurate range of where they should be for fitness.

Maximum VO2. When we talk about maximum heart rate, it does not equate to maximum VO2. It is somewhat of a linear relationship, but it is not a perfect linear relationship. You can see, if we look at our maximum heart rate, our 70 to 90% range, we are only getting into the 58 to 83% of our maximum VO2. This is great for fitness but not great for performance. For performance, we are really going to have to get up to that 80 to 95% of your maximum heart rate.

The other way that we can gauge is what we call the rating of perceived exertion, and we look at the Borg scale. If you look at the rating of perceived exertion, you will sometimes see charts and we will have someone pick out, "Okay, I feel like this is what it is." Now what is interesting about the Borg scale is they have done a couple of studies that I am familiar with, probably more than I am familiar with. But what they found is that this was a very valid way of figuring out where they were in their VO2 max.

That when someone picked out light, they were in that 31 to 50% VO2 max and it did not matter if they were an untrained or trained person, it is all relative. If they were at, for example, if this was hard, yes, that equated to 85%, the VO2 max or 92%. They were really at the top end of their training zone in terms of fitness. You can see that this could be something very good to use.

I know a lot of people, I have had students say, "Well, I do not like the scale, it makes no sense." The scale makes a lot more sense if you add a zero and consider this heart rate. Let us say instead of 68, we would say this is like 60 to 80. Or let us go back in here to the heart, if we looked at this is 150 to 160, let us see at a heart rate of 150 to 160, this starts to make more sense.

I know some people have tried to make a modified board scale, which is 0 to 10. This makes a lot more sense to me. This is a valid tool that you can use for having people just point out on a chart where they feel like they are.

Some of the adaptations we see with exercise. We see resting heart rate decrease, we see blood pressure decrease. Then we talked about the athlete's heart. This is a model that we have had for several years, which talks about moderate cardiac hypertrophy with training. In the original studies, it is shown that left ventricular volume increases with aerobic fitness but ventricular wall thickness increases with strength training.

The feeling behind this was that you are increasing the blood pressure so much this is what creates that adaptation of wall thickness. Now, something to keep in mind - this concept was based on Modern World Studies in the '70s at the University of Wisconsin. Since then, technology has gotten much better. We can see the heart a lot better than the basic echocardiograms that they were using. The concept is changing. Adaptations in increases in ventricular mass are not "true" when you normalize it to changes in lean body mass.

What we are seeing is, that whereas the model still focuses on left ventricle adaptation, now it is focusing a little bit more on right ventricle adaptation. That is because the end-systolic wall stress is relatively greater than the left ventricle due to the increases in pulmonary artery pressures. Ventricular arrhythmias and elite endurance athletes are associated with the right ventricle. Relative right ventricle enlargement and reduced right ventricle, ejection fraction is expected in athletes and should not be considered pathological.

Sometimes that is one of the things we must look at is some of these changes, physiological changes are viewed if someone's going to a primary care physician and they do not know enough about the adaptation sports, they may see some of these physiological adaptations. It is pathophysiological. I ran into this trouble in college, as someone who ran track when I went from my pre-participation physical. I went to my primary care physician and my resting heart rate was 48 to 54 and he ran all these tests on me. I tried to explain that it was a normal adaptation. He did not realize it. This would become a factor when we talked about our ECGs in a few minutes.

Cardiovascular drift is a phenomenon I want you to be familiar with. It is a progressive increase in heart rate and decrease in stroke volume that begins approximately 10 minutes into prolonged moderate-intensity exercise. Drift is greater during hotter temperatures. What we see is we think that when it starts to get hotter, we are going to have a shunting of blood. Remember, before we talked about how the blood is shunted to the muscles.

We are going to see how the blood is shifted to the periphery to help with heat stress and to help release some of this heat. What will happen is some of his blood is now shunted to the periphery, so your stroke by him decreases, so your heart rate will increase to make sure you are getting the same amount of blood. Let us say you are working, and your heart rate is at 160, after 10-15 minutes, especially in the heat, you may see this go up to 180, and this is just a sign of metabolic stress. You may just have to lower it down a little bit. I want you to be aware that we are not quite sure exactly why the drift is occurring. We have these theories, but it has not really been proven yet.

When we look at heart rate variability, a lot of people are using this now as a way of helping athletes with their training sessions, and how hard they should be working out. You will see GPS systems, catapult systems, and several different things to try and figure out. It is all based on recovery, making sure that athletes have enough recovery after their training sessions. The heart rate variability and objective physiological measurement of the interval between consecutive beats. Keep in mind, that if we talk about it, someone will say, "Oh, yeah, my heart rate is 60 beats per minute." Well, that is the average, but it does not mean that they are having one beat, every second one beat could be at 1.1 seconds, and one beat could be at 0.7 seconds.

What happens is this variability is normal and is a sign of good health. If you look at healthy biological systems exhibit complex patterns of variability that can best be described as mathematical chaos. Your ability to variable someone who is one beat per second on the dot would indicate that they probably are not responding to the instantaneous changes that are always occurring in our body.

Measurement of heart rate variability. The next couple of slides will be a little bit technical and may not make a lot of sense but I will tie it all into what I think is something that is understandable and easy to use. When we look at the measurement of heart rate variability, we can look at the time domain which is the interval between successive complexes.

Remember, we talked about, do you want the Q? The R? The frequency domain measures. This is plotting the frequency at which the interval changes. Then we talked about low-frequency to high-frequency ratios. When we are talking about frequency ratios, a lot of it also depends on how long you are taking your heart rate when you do this. This is what I mean, which interval are you measuring? The R-to-R interval is the easiest one to pick out. That is usually what is measured when we look at a lot of these algorithms.

You can do ultra-short-term and short-term heart rate variability. You can look at the dynamic relationship. When we talk about what is variability, and what is occurring. Well, in the short term, we are looking at the relationship between the sympathetic and parasympathetic branches and the regulatory mechanisms that control the heart rate via respiratory sinus arrhythmia. If you investigate 24-hour heart rate variability, you are looking more at circadian rhythms and core body temperature metabolism.

This is the gold standard 24-hour heart rate variability which athletes do not use. This is what is used in hospitals. They can almost predict if someone is about to have a heart attack based on this heart rate variability. But this is a hospital situation. What we are seeing in athletics is, in fact, for the most part, we are using short-term heart rate variability. If you are looking at some people who are using the rings and the Fitbits, and things like that, where they are using two minutes. Two minutes really is not enough to get good feedback as to what is going on with heart rate variability. I would suggest to you a minimum of 4 to 5 minutes if you use it.

Also consider the equipment that is used. If you are looking at high-level teams, like in the EPL, the different academies, they are using their systems where they are almost wearing a training vest. In fact, you will sometimes see it in the game, where that vest has a GPS system which is giving them speed, it is giving them feedback, heart rate feedback, and things like that. When I use it, what I use is just use a heart rate monitor, but I use a chest monitor that I can strap on. You are going to get much better reliability in the information and the data that you get from something like that as opposed to a ring or a wrist bracelet.

This is a study where they looked at cardiac electrical conduction, autonomic activity, and biomarker release during recovery from prolonged strenuous exercise in trained male cyclists. They looked at the ECG intervals obtained from eight highly trained athletes before, during recovery, and 24 hours after a prolonged bout. Now, this is the root mean square of the standard deviation. All right, that is the domain that they were measuring. It was significantly reduced during recovery. That suggested a suppressed parasympathetic, and/or a sustained sympathetic modulation during recovery. If by looking at this domain, this root means a square of the standard deviation, if you wait and you just monitor when it starts to increase, that is when you know the athlete is recovering from that training session.

This was a session on individual heart rate variability responses to pre-season training in high-level female soccer players. When we looked at this, they were looking at training loads, as you can see, and it showed very large relationships with the weekly changes. Once again, the root means the square of the standard deviation, the averages. The increased training load was associated with a decreased mean, the decreased training load was associated with an increased mean. If it was unchanged, you can see no substantial changes. By using this, using looking at the reduced mean, along with the reduced mean in the variance that was related to non-functional overreaching. Non-functional overreaching is the training response that we want. As opposed to functional overreaching, which means they were overtraining.

The increased values indicated that there was an upward and downward change throughout the week. You can have a coach who has a whole training session laid out. When we are going to do this, this, and this. But if using heart rate variance, you may say, "You know what, they do not have enough recovery to train this hard the next day." That is basically all this is saying.

Here is something I use, a lead heart rate variability and this is the app that I use. I use a Polar H10 heart rate monitor, and I strap it on every morning. I just sit quietly for 10 minutes after I wake up. This will give me based on the algorithm that will tell me what my relative balance is between my sympathetic system and my parasympathetic system. On this day, my heart rate variability was 41, and I was in perfect balance.

To really use this as an effective training tool for how you want to do your training sessions, you must monitor this over a period of time. It took me about six to eight months to realize, so, even though I am doing the heart rate variance at the same time, you keep a training log. What your training session was, how much sleep you got, any other factors that you want to do, if it was an extremely stressful day, things like that. That all feed into the equation, it gives me an idea.

For example, let us say, I woke up one day, and after my training session, and I was maybe like a four or five on parasympathetic, indicating I was more into parasympathetic influence so I would get a recommendation of maybe some rest or recovery day or something very easy. What I found out is by monitoring myself, if I was at four or five parasympathetic, maybe for that day I had scheduled 10 intervals on the treadmill sprints.

Instead, I would not want that much volume instead, to try and come under the more sympathetic influence, I would do a high-intensity, low-volume day. Maybe I might do a deadlift day or a power clean day, where I might just do four sets of one to two repetitions. Something intense but low volume to see if I can come more into sympathetic influence.

The opposite is also true. Let us say that day I was scheduled, I want to do a 45-minute run on the treadmill at about 70 to 80% of my max heart rate. But that day, I came in and turned out I was a little more sympathetic, well, then maybe I would go slightly more parasympathetic instead of a 78%, maybe I would just go maybe 50 to 70% of my heart rate to make it a little bit easier to get my workout in but try and come on to more of a parasympathetic range.

These are things that you must play with. It is not one size fits all, but it can be very useful. A lot of athletes are using this to help with their recovery so they can prepare. This way they do not go into an intense training session at a deficit so that they can take advantage of a high-intensity training session.

The cardiovascular function. We are looking at hypertension, which is one of the most common medical disorders. Even though this is not sports-related, it is more patient-oriented. Exercise will lower blood pressure. I mean, the World Health Organization will tell you one of the primary ways of treating should not be pharmaceutical unless really needed in their comorbidities. You should try for a few months just doing some basic exercise.

The effects of exercise are most noticeable when it comes to blood pressure during a meal or after a workout. Lowered blood pressure can be most significant right after your workout in a session. But if you want that cumulative effect of lower blood pressure at rest during the day, you are going to have to basically train for two to three months to try and get this effect.

KAATSU training, which really means it is the forerunner of blood flow restriction, but KAATSU training started its origins in the 1960s. Dr. Yoshiaki Sato found out about it almost by mistake. He was kneeling, in the kneeling position, he felt when he kneels for long periods of time, he got the same swelling in his calves that he was getting from his weight training when he was doing it. He was just trying to figure out if there was a way of maybe occluding the blood flow, so you get the same workout without training as hard. That is really the origin of it. He worked with it now.

We will talk about some of the side effects. When we talk about 13% of subjects report small red spots that disappear after a few days, well, if you are not careful, you can have more side effects. He ended up at one point with a thrombosis because he had too much pressure on with the bands. He kept experimenting on himself but where it really came very valuable for him, even though he was hospitalized at one point or got out but then he had a serious ski injury. He ended up using these KAATSU training techniques, these blood flow restriction techniques to help him get back and regain his strength and help prevent muscle atrophy. Basically, you are trying to create metabolic stress. Let the body get metabolic stress without having to use its higher load by restricting the blood flow in the first place.

The risk for more serious conditions such as venous blood clots and severe muscle breakdown where has been minimal, but it can happen. I am surprised it has not happened more because when you have something like this, you have a lot of people in the gyms working with it and trying to figure out what they can do and they do not want to spend money on decent equipment, so they start using everything from tape to just weightlifting bands, which are not designed to occlude blood flow.

You also get numbness and feelings of cold due to compression. They would be temporary, and they do resolve after the release of pressure. When we talk about this, we talk about the use of this for conditioning and training, I really think this is more a technique that would be used for rehabilitation.

When we looked at blood flow restriction exercises and sprinters and endurance runners, what was interesting is blood flow restriction protocol using 20% of one rep max appeared to benefit endurance runners more than sprinters. The reason why was because sprinters operate at such a high intensity, they were already getting incredible metabolic stress. They do not need anything more than what they are getting. Whereas endurance runners, you are not getting as high blood pressure. The blood flow restriction protocol uses 20% of one rep max. That appears to be what I have seen in most of the research. What was interesting is I did try blood flow restriction on myself after knee surgery, I had a replacement of my right knee. They tried that protocol, and I was fascinated. I got a good effect, but I was very sore.

This is not a comfortable technique by any means. This is very uncomfortable because you are trying to create that metabolic stress. The reason to become so good at rehabilitation is you do not have to use an intense load by occluding the blood flow. You can use a lighter load that will not damage the structure, the muscular or the bony or the connective tissue structure. But I felt it was quite intense.

I just want to go back here for a second. I did not want to show a lot of different studies on this but my recommendation to you is I do not think it is beneficial for athletes. I think it is more of a gimmick for athletes. They just need to train hard, and I feel it is much more useful for rehabilitation. I know in the United States, the FDA has only approved the Owen System. I don't know much about it or what it is, but you will see a lot of fake products like tourniquet type devices sprouting up in the gyms, where a lot of people, healthy athletes are using this method. I do not see why they need to do this and if they just lift heavy, you are going to get the same effect without as much risk.

Just a brief talk about exercise and coronary heart disease, looking at the risk factors and making sure that we focus on the modifiable and not the non-modifiable exercises. As you can see, diet, exercise, smoking, and stress. This is what we should be focusing on.

When we talk about getting patients ready, a pre-exercise evaluation can be very helpful. We have our PARQ, the Physical Activity Readiness Questionnaire, which was developed in Canada. Some of the modifications were physical activity readiness, medical examination for pregnancy, and PARmed-X. You can also use stress tests for evaluation. You are not going to use a maximum stress test on people unless they are a well-trained athlete or in really good shape. Generally, you will use something submaximal. You can get the protocols like a bulky treadmill protocol. A lot of these, there is a publishing company called Human Kinetics, where they will have a book on all the different protocols, I have used high school athletes to get a whole team and I have used a step test using bleachers, the bleacher steps.

When we look at cardiac hypertrophy, once again, this function versus pathological. We talked about increasing right ventricular volume, and about the changes in arrhythmias, which are functional, not pathological but the number one cause of sudden death in older athletes is coronary artery disease. These are our master's athletes or older athletes. Young athletes are the ones who are at risk for cardiac myopathies. This can be very hard to pick up on our pre-participation physical unless you are using ECGs.

Talking about ECGs, for a second, the primary screening tool is the pre-participation history and physical exam. But just doing the history and physical exam appears to lack the sensitivity to reliably detect the causes of sudden coronary death. These were the Bethesda guidelines from 2005 that shows the ECGs will reliably diagnose up to 75 to 95% of athletes with hypertrophic cardiomyopathy. Why do not we use this more? If people are worried, at least in the United States, they are worried about the cost because of a number of false positives that are sometimes attained with the ECG.

Electrocardiograph evaluation in athletes and use of the Seattle criteria to improve specificity. This is an international consortium that was designed to try and weed out these false positives that you are going to see in athletes who are in really good shape. The whole idea was to figure out, "Okay, we need the cardiologist to know what physiological change is, and what is pathological."

This is the international criteria, if you want to look this up, there might be a recent one, I think every two or three years, but with COVID, we have had a bit of a problem, in terms of getting this group together. This was 2017, British Journal of Sports Medicine. I don't know if there is an updated one yet.

But basically, what they are looking at is, they say, "Here are your normal ECG findings. Here are your abnormal ECG findings. Will you go straight to further evaluation?" But there are several borderline ECG findings, which will give you a false positive, which do not necessarily have to lead to further evaluation.

If we look, for example, at a completely right bundle branch block, and if that is all they have, and they do not have any other comorbidities, and they do not have a family history, then that would be a normal positive finding and you do not have to do anything more about it.

But it just gives you a better idea as it will weed out, for people worried about the expense, it will weed out some of this. It is a shame we are talking about expenses when we are talking about sudden-death situations. We have seen some of these situations arise on the pitches in some of the different leagues. It is a good idea to have it. I always have the automatic external defibrillator and when we look at the ECG, if you are talking about international competition, certain federations require the ECG.

A lot of the federation requires this including the IOC. In the United States, although not everyone requires it, it is recommended. When we do our high school pre-participation exams, we do a standard 12 lead ECG screen. We are doing that but not everyone is. Recommendation. I am pretty sure FIFA, and all international competitions are requiring it, which is a good thing.

Let us look at possibly designing an aerobic endurance program. When we are looking at the different factors that we want to see and based on what we know now about cardiovascular anatomy and heart rate variance, first, you want to choose an exercise mode, whatever it might be. Then you are looking at training frequency, training intensity, exercise duration, and exercise progression.

What type of exercise do you want to look at? Keep in mind - swimming, cycling, running, cross country skiing, and rowing, when you are doing these, these physiological adaptations are specific. If you get a cardio benefit from swimming, it does not mean it is going to transfer over to cycling or to running. The reason I listed swimming, cycling, and running is because these are our triathletes. If they want to get the physiological adaptations, they must make sure that they are training intensely in all three. That is why it can be so tough, sometimes when we are talking about preparation for the triathlete. But will they get some crossover? Minimal. Not enough to compete at the elite level. That is the mode that we are talking about.

The training frequency, and number of sessions per day or per week. Once again, it depends on how intense you can be. You can train every day, but you cannot train intensely every day unless you are keeping the volume down low. For example, there are some weightlifters who are training intensely maybe 6 or 7 sessions a week, but their intensity is based on load, not on volume. That is why they might be able to get away with it, but they still need some lighter days.

Training intensity must be high enough to overload the body to get the desired adaptation. Regulation of intensities monitors in different ways. Once again, we can do it by VO2, we can do blood lactate, we can do heart rate variance, or we can do ratings of perceived exertion. But you want to have some way of monitoring this. VO2, unless you have a gas card or something like that, VO2, you are probably monitoring heart rate. You are looking at that relationship even though it is not linear. Blood lactate is a fairly easy way to do it and I know several teams will do blood lactate to try and get an idea of how intense the session is. My favorited really is heart rate. When I say heart rate, I am talking about heart rate variance and monitors.

Your exercise duration - length of time of the session which is usually related to the intensity of the session. If you are going very intense, you are looking at a 20 to 30-minute session. If you are talking about max VO2, maybe you are going 120 to 180 minutes, depending on what you are training for. I would tell you that in a session where you train 85 to 90%, let us say you are doing intervals, maybe you are doing 400-meter intervals in terms of exercise. Obviously, that is not aerobic that is anaerobic, but the actual amount will be different. If we are just talking about aerobic training, then yes, then 20 to 30 minutes is more than enough at a 5% max VO2.

Then your exercise progression. How do you manipulate the frequency intensity and duration values? There comes a point where it is very tough to increase some of these values for high-level athletes. They are already training almost every day. They are already training at maximum duration. The only thing you do is maybe increase the intensity at that point.

With elite-level athletes, a lot of times it is more a question of decreasing some of these variables and increasing them. They are already trying to go max and sometimes you must rein them in a little bit to get better performance. If you do not remember some of this, there is an acronym, FITT, Frequency, Intensity, Time, and Type. If you keep all that in mind, time obviously is the duration. Type is the mode up in here number one. But if you keep this in mind, you will always remember the different factors that you have to consider when you are designing a program or monitoring a program, or you are just talking to the athlete about it. The one that is not here is obviously exercising progression.

What are the different types of aerobic training that you can do? Well, there is a long slow distance, there is pace/tempo, there is interval, high-intensity interval training, and fartlek training.

Long slow distance. Some people confuse this because, in the '70s, there was a concept in the United States, I do not know if it was in other countries by Joe Henderson, long slow distance. Long, long miles at a slow pace. That is not what long slow distance training should be. Slow just means slower than your race pace. You are training at about 70% of the VO2 max, which is still a nice pace, it is just not race pace but allows you to go for a longer period. Then you can get improved cardiovascular function, you can start improving your thermoregulatory function, and you increase your utilization of fat as an energy source. The enzymes increase so you can mobilize your free fatty acids easier. This type of training does not stimulate neurological adaptation of muscle patterns used during a race. You will use this to some extent, this might be something you use off-season or almost as a recovery type of pattern.

Pace/Tempo training. You are using an increased intensity, or you go slightly faster than the race pace that the athlete uses. This will correspond to the lactate threshold. You really want to get a little bit like you are crossing that line into the anaerobic range. This is sometimes known as Threshold Training. Generally, these sessions are 20 to 30 minutes of Pace training.

Interval training. You are exercising intensely close to your VO2 max. Intervals that last 3 to 5 minutes. Then you gradually increase the workout to rest ratio to 1:1. You may start the intervals, 3 to 5-minute intervals where you are doing a 2:1 rest to work ratio, or 3:1 rest to work ratio, and gradually get to 1:1. These are very stressful, they really need a good endurance base if they are going to do this type of training.

High-intensity interval training. Using short high-intensity intervals with brief recovery periods. Athletes need to go above 90% of their VO2 max for several minutes. The rest periods are usually a little less than the work interval when you are doing this because you are really trying to put yourself under metabolic stress when you are doing this type of thing. Something to consider when you are doing this type of thing, let us say you are a 10k runner and you want to get your mile pace, it may be 5-15. Then you might be doing high-intensity, half-mile training at maybe 2 minutes, 20 seconds, and you do a couple of these and that is how you do your high-intensity interval training.

Fartlek training. The Swedish word for speed play. I hope I got that right. An exercise session of easy intensity interspersed with brief intervals of higher intensity. This might be, let us say you have a team of runners like eight runners. Well, they would run paired up two in a row and what you will do is run at a certain pace, and then the two runners in the back must sprint up to the front.

Then you run this way for 10-20 seconds. Then the two runners in the back now sprint up to the front. You have a nice easy pace, but you have to sprint, maybe you are getting a sprint every 60 to 120 seconds. Now you are combining your VO2 max and now you are getting into a little bit of lactate threshold. This really helps with your ability to use your substrate metabolism. It really starts increasing enzymes for those metabolic pathways.

After discussing this, this is out of Runner's World where someone who might just be starting, let us say you have someone who is starting or an athlete who is recovering, a very simple way of looking at this on a seven-day basis for a seven-week program. Okay? So, 15 minutes, 25 minutes, then on Wednesday, this could be rest or a 15-minute interval. If you are an older athlete or someone who is starting at an older age, take the rest and maybe use it as a stretch day or do some yoga. This will go for seven weeks, but I want to show you how you manipulate some of the variables.

Here is Week 7 of the chart I just showed you. Let just say now you want to start increasing intensity for an athlete. What you can see in Week 8, is you go from 20 minutes on Monday to 20 minutes on Fartlek. Let us say start doing some speed play. Then on Tuesday, you go to what was 45 minutes now you go to 60 minutes of long slow distance. Then Wednesday, which was a rest for 20 minutes — I just say rest, just rest it up. Make sure you are ready for the next couple of workouts. Thursday you go from a 40-minute session to now a 30-minute with interval session. Friday was a rest day in Week 7.

Friday is a 30-minute-long slow distance. Saturday, which was a 60-minute easy run now becomes a 40-minute Fartlek. Sunday is rest. You can see it went from a total of 165 to 185 minutes for that week. Now, in Week 8, it is only 180 minutes, but you have increased the intensity on a couple of days. That is how you can manipulate some of your variables for aerobic or endurance training. These are general guidelines. Obviously, this would apply to some of your high-level athletes.

Looking at recovery, when we talked about recovery, there is immediate recovery, and that would be what occurs between rapid movements. Short-term recovery, which is really what we see more during exercise sessions between sets of an exercise, or between intervals. Then your training recovery, what are you doing between successive sessions or competitions?

It depends on whether you are doing a non-steady versus steady state. If you are talking about going out for a 10k run at a steady state, well, then you are going to end up with a different metabolic pathway versus a non-steady state, like a soccer player who is sprinting, resting, sprinting, resting. In the non-steady state, for example, they might build up some lactate. For them, you are going to look more at active recovery when they are done with a game. Maybe a basketball player when they are done with the game, they have gone into that lactate threshold. It is not a bad idea now to metabolize some of that lactate with an active recovery, which could be on a stationary bike. It could be an easy run, but you are talking about, 40 to 50% of your VO2, so you are basically now just using the lactate as an energy source versus having run a 10k where now you want passive because you want to make sure that you have just been replenishing your energy stores.

If you have, especially younger athletes who sometimes have tournaments, the recovery recommendation is, first to make sure you rehydrate. You replace your energy stores. But after the game, once you get to metabolize lactate, you will use an active recovery system.

There are several different ways of recovering. Heat is a good recovery tool. Massage is a good recovery tool. It seems to help the athlete. We have not seen a lot of evidence on it. A lot of this is anecdotal, although I have seen some nice recovery studies on using heat after exercise sessions. But when they talk about heat, when you talk about actual changes, you are talking about getting into maybe 43-44 degrees centigrade, or maybe 107 degrees Fahrenheit, to really get some of these benefits. I do not know how many of the athletes are getting into that range, but foam rolling is something I see a lot of my athletes use and can be used as a recovery tool after an intense battle of physical activity.

Like a lot of different things, we see. We are going to see contradicting reports. We are going to see some evidence that foam rolling is good, and some that say it is not. This is the nature of the scientific process. A lot of times what you want to look at is you want to see, well, on the studies that say it is helpful, what is their methodology? On the studies that say it is not helpful, what is their methodology? Who were the subjects involved in these studies?

This was an interesting study. Twenty physically active resistance-trained males, the average age of 25.1 years, did 10 sets of 10 squats. They really worked the muscles, and there was a control group in a foam rolling group and the foam rolling group rolled at the end of the exercise session 24 hours after, and then 48 hours after. They did five exercises. They worked all different sides of the thigh, and they did the gluteal muscles. Each exercise was done for one minute twice on each side. The total time of this foam rolling session was 20 minutes.

What they found out is the foam rolling group had substantially less perceived pain. The foam rolling group performed better in the vertical jump than the control group. This was a result of maintaining pretesting values better than the control group. They still had a decrease, but they had less of a decrease. I would tell you that I think foam rolling is a nice recovery tool.

Let me just go back to this for a second. Now when we talk about foam rolling, where I see the relationships between these studies that say it does not seem to help and the studies that say it does seem to help. The studies where it seemed to help usually, or post exercise and they usually spent 10 to

20 minutes during the recovery session. If they are just doing it for two or three minutes, they are probably not getting the benefits. That is where the evidence goes.

How about foam rolling before the workout to see if you can potentiate the workout? Not a lot of evidence about this. But for people I have seen who have said, "Hey, foam rolling is a waste of time, it does not really work. There is no evidence that suggests that it works." You know, that might be true, but there is also no evidence that suggests that it is causing any damage.

If I have an athlete who tells me, "You know what? I really feel great. I think it really helps me and I have no evidence that says it is going to hurt",

Why would I tell them not to do it? Why would I say, "Well, the evidence does not support it?" They will probably tell me where to stick my evidence.

There becomes a point where, well, they feel better with the foam rolling, and if we really look at the psychosocial model of health and of exercise, well, if psychologically, they feel better, that is going to be a benefit to their exercise even though we may not have evidence that it helps them on a physiological level.

That is my take on that. I think some people get too carried away with evidence, but I have something that I think helps psychologically, and there is no evidence that shows it is going to be a risk, I think it is a good idea to continue with that type of technique.

That completes this second session.

[end]