ICSC Culture Diversity Module 08
ICSC08 _ Section 3_Exercise Physiology
Instructor: Andy Klein
Video Lesson: 01:27:39

This is the third module of exercise physiology for FICS. We will be covering a couple of different topics in this final lesson. This is the agenda where we will talk about speed and agility, plyometrics, program design. At the end, I will talk on environmental stresses.

Let us talk a little bit about some of the different definitions that we have, so we are on the same page. We will be talking about speed which is the ability to achieve high-velocity movement, about change of direction, and that is the ability to explosively change direction and velocity. Then we want to talk about agility which is sometimes I think misconstrued. It is the ability to change direction and velocity in response to a stimulus. It is one thing to do all your drills for speed and everything, but how does that translate into a playing situation when we go onto the field or onto the pitch?

When we talk about speed, how fast are you moving? The velocity, how fast are you moving in a specific direction? Acceleration, the rate at which that velocity changes, and deceleration which is negative acceleration. From a practical point of view, I spend a lot of time on deceleration. I think people overlook this concept because let us say you are on the pitch and you have to change direction, well, you have to first decelerate. If you do not have good deceleration ability, which is a function of strength, it is very easy to hurt yourself or it is very easy to slow down where you can really lose your pace as you are playing. This is where you will see a lot of people, for example, when we are on the field, where you see one player out jukes another (Juke meaning: that awkward moment in the halls when you and some other person are trying to go different ways but you can't get around each other) or just really lose them, it is because one of the players can decelerate a lot quicker than the other player.

Let us look at rate of force development as a function of time. Rate of force development is comparable to strength and power when we talk about it, but if you look at the difference, let us say you are untrained. You can see they can eventually get to the maximum strength in 500 milliseconds. Versus the person who is in resistance training, someone who is in the weight room and doing a lot of heavy weight training, you can see they also get there about 500 milliseconds, but you can see how much more strength they have. The important thing is the athlete who trains explosively or ballistically, they can almost get to their point, their maximum strength at about 200, 250 milliseconds.

Why is this important? Well, it is important because when we look at different aspects of sport, you can see that the movement will be rather quick. Let me go back here for a second, at 250 milliseconds. If you look, for example, at a runner, a runner when they hit their contact time on the ground, a sprinter, it is about 80 milliseconds. They are very quick, but they are not using their maximum strength at that point. What you are doing is it is a function of velocity, it is a function of power, and that is what we will look at in further detail.

Speed is a neural quality. Boo Schexnayder is a well-respected track coach in the States. He was with Louisiana State University, LSU, and his team basically won the NCAA, the college championships for 5 years in a row. One of the reasons is his training, is he understood that it is a neural quality that you must improve your neuromuscular integration which includes recruitment, rate coding, synchronization. When we talk about recruitment, it is an interesting thing because recruitment, if you want to recruit the larger muscles, your type 2 muscle fibers, if you want full recruitment, you must get to 90% of your maximum voluntary contraction. You are not going to recruit all the fibers if you are working at 60, 70%.

When he talked about training the nervous system, it is quality of work, long risk, low volume. If you are training for speed, that is all you train for in that training session, which means if he has a sprinter, he may have them, maybe he will be doing 100 meter runs.

Well, he does 100 meter run at top speed and then they will rest 4, 5, 6 minutes and they will do another one. If they start decreasing by 10% or more of their top speed, the workout is over, training session is over. Like he says, I am not training you to be slow, I am training to be top speed. They are trying to build up that neuro quality, try and create those engrams, that cortical facilitation, and that is on just strictly with speed. Afterwards, they may rest, maybe go to the weight room, but if it is a speed workout, that is all they do. If you are slowing down, you no longer train to be fast, you are training to be slow.

Sprinting, it involves the relationship ship between stride frequency and stride length. Your stride frequency is dependent on metabolic system, so that is what we talked about previously when we talked about ATP. When we talk about ATP and creatine phosphate, these are your metabolic pathways for very fast explosive movements. You can see your stride frequency that when you get up to about 3.8, maybe 4 strides per second, you can see how fast you are going. That is when you are starting to hit top speed.

You can see there is a certain point at the stride length where your stride length will increase with stride frequency to a certain point and then you really are not going to increase your stride frequency anymore. That is, it, your stride length, it is going to max out. The stride length will typically max out about 2.2 meters, and that would be for someone who is about 6 feet tall, or I think that would be about maybe 180 centimeters, 1.8 or 1.9 meters tall, and that is going to max out 2.2. If you start increasing your stride length too much, you will start slowing down.

Here is a typical example, Usain Bolt and all the other sprinters. His stride length based on his height was 2.46 meters. His stride frequency is much greater, too. He only needed 40 strides where all the other sprinters needed 44 to 45 strides in the 100 meter dash.

When we talk about sprinting technique, we talk about the start, and that is coming out of the blocks from a standstill position. Your acceleration, those initial steps are vital, and this is producing your ground reaction forces. Hopefully, it is more vertical reaction forces into a horizontal position. That is what we are looking at. Top speed, also known as maximum velocity. Here is the thing, this is starting out of the blocks, but we deal with so many athletes and this is their starting position, from an athletic position or from a rolling position, where they are just moving slowly and then they have to all of a sudden explode out of it. You are not getting that maximal, what we call, triple extension movement. Your triple extension is coming from a standing position.

When we talk about starting with your out of the blocks or just in an athletic position, the whole idea is aggressive extension with both legs, although one leg will be a little more dominant. Even when we talk about leg dominance, when you say, "Well, what is your dominant leg?" It is often defined as well, what leg do you kick with? If you kick with your right leg, we really should define that more specifically as your flexion dominant leg because when you are kicking with that leg, what is your other leg doing, it is planting and creating whip-like motion. Your plant leg becomes your extension dominant leg. A lot of times, from a standing position, athletic position, you will have one leg which is going to be a little more aggressive in terms of extending out.

The vertical forces, they overcome the static position in the stance phase, but those vertical forces are at an angle because you are trying to initiate a horizontal force. You are not looking to just jump in the air although sometimes, with some athletes, that is exactly what you are doing, a basketball player or even for a soccer player who is going for the header.

The current literature suggests that the biggest difference between elite speed and average speed is the amount of vertical force applied to the ground. How would you increase this? You would increase that with training.

Looking at the phases of stride. Let us look at that stance phase right in here. When he lands, what is going to happen is, it is going to be an eccentric breaking. You want as little as possible because you want to transfer your speed from one strike to the next as quickly as possible. You are going to have an eccentric landing, and this is what we call our amortization, and then he will have concentric propulsion and then he will go into his triple extension. You can see this leg just finished a triple extension which is extending the ankle, knee, and hip.

Then we get into our flight phase. Here is our flight phase with the recovery, you have a leg swing for ground preparation. You can see that triple flexion position right in here on all three of the athletes, you can see it, where you are flexing the ankle into dorsiflexion and you are flexing the hip to drive that leg forward. On this athlete trailing the play, you can see that this is that triple extension that we are talking about and this is the triple flexion as he prepares for his next stride.

If we want to improve performance, we want to improve strength during the support phase, we want to have strength against gravity and we want to create those propulsive forces. We want to improve swinging actions, which is the speed of circular movements, the speed of reversal. How quickly can we bring the legs around?

When we look to improve performance, one is, for strength, we can do weight training, we can do plyometrics, we can do contrast training. Contrast training is going to be different. People use this term differently and they are not wrong. You can do contrast or complex training where maybe you are doing, for example, in a previous session, we talked about, maybe you will do squats and then go into vertical jump, but you can also do contrast training in terms of applying resistance or assistance.

Let us look at sled pulls. I have 2 different diagrams of sled poles. You can see he is pulling a lot of weight, but one of the things is, if you are pulling too much weight, are you in the position that you want to be in? I mean, this is not a very athletic position. You can look at the flexion of the lumbar spine, this is not a good position. He is probably carrying too much weight; this is not a great position. If you are going to do sled pulls, shoulder harnesses or waist harnesses work much better because you can see this athlete is in a good sprint position. That is one of the things we look for sled pull.

When you are doing sled pulls, the whole concept, are you doing sled poles for strength and power, or are you doing it for speed? If you are doing it for speed, it is going to be a lightweight. For athletes who might be doing sled pulls more to just provide a little bit of resistance but at the same time still keep in with the motor pattern of sprinting, one of the things you can do is time them. When we are working with football players here in the States, what we will do is, let us say they can run a 4.5, 40, 40-yard dash, they can do in 4.5 seconds.

Well, when we put weight on the sled, we will time them. If they go slower than 10%, if they run a 4.8, that is good. They are developing the speed that we want, just stimulating a little bit more. Let us say they run greater than that, 10% of 4.5 would be a 0.45 seconds, so if they run a 5 second or 5.1 second, that is too much weight. We are interfering with the actual concept of training for speed.

You can do sled pushes, as well. What angle do you want to work at? Here, we have a football player, this is a more athletic angle, but what if you want to go lower? You can use a sled push and you can go with a higher grip. I mean, this is perfect, if you want your rugby players to maybe work a little bit more in that position like when they are getting into the scrum or getting into the rock, you might want more of a low sled type push, and this is where you develop.

How do you want to work? Let us say we are talking about a rugby player now and you want them strong in their work. Well, a lot of times, the rock and the scrum are not velocity-based, it is more strength-based. In that case, it might be good to really load up the sled, so they get used to pushing a lot of weight in that strength and explode out of it. There is a certain power component in there, this would be more appropriate for, let us say, a bobsled athlete because they are going to push as hard as they can. They want to develop speed. A rugby player, not as much. They want to develop more power, so we can load up the sled at that point.

We can also use bands. We are talking about resistance. I have been dealing more with resistance, you do resistance. This is an example where this athlete would start running and this athlete would run behind them. You would have movement in there or you can do assistants. With assistance, you can use a bungee cord, this is almost after the release. What would happen is you can have a bungee cord and create a lot of resistance so the athlete would almost have to fight against being pulled at the very start.

Then when they start their sprint, not only are they sprinting, but they are getting the elasticity, the bungee cord pulling them. With that, they can have an increased speed. Then the athlete who is over here will release it and then they will just run through for a 20 or 30 meter sprint, something like that.

A lot of the resistance and assistance exercise, we have seen resistance with parachutes. I have worked with parachutes before. I am not crazy about working with the parachutes. I think, for a lot of athletes, I see they change their motion and then on a windy day, you might be dependent on when and you might be getting different vector. I am not as big a fan of parachutes, I have not been using them in the last few years.

Some of the interesting research when we are looking at the muscles in terms of sprinting mechanics in sprinters? One of the things we see is compared with untrained men, sprinters had significantly greater thigh muscle volumes of the hip flexors and extensors, adductors, gracilis and psoas major. I am not sure this is going to be a surprise to you. I think that the big surprise is, how do we work the hip flexors because most of the exercise we are doing is that triple extension mode?

Working with the hip flexors can be a little more difficult. We do not have as many machines. You are going to end up using bands. You are going to end up maybe using weights attached to the legs, to the feet. If we will look at monoarticular knee extensor and flexor thigh muscle volumes, they were similar between the two groups. Hip flexion training appears to be much more appropriate for sprinters. Some of that, you will get help just by sprinting fast. How do you run fast? Run fast.

It sounds almost ridiculous to say that, but that is what you are going to do. How can you maybe increase some of the hip flexor strength? Well, you can do things like maybe running up a hill. Running up a hill or running a treadmill at maybe a 3% or 4% grade is very similar to the mechanics that we see with acceleration in sprinting.

Trunk and lower limb muscularity in sprinters. What are the specific muscles for superior sprint performance? This was last year. Absolute relative cross-sectional areas of most trunk and lower limb muscles, including psoas major and gluteus maximus, were significantly larger in sprinters than in non-sprinters. The absolute and relative cross-sectional areas of the psoas major and the gluteus maximus correlate significantly with personal best 100-meter sprint time in sprinters. I think with our patients and our recreational athletes, a lot of times when we look at the hip flexors, we talk more about stretching than we do about actual strengthening when I think we must change our focus and really emphasize more the hip flexor training.

The muscle morphology of elite sprint running. We investigated the differences in muscle volumes and strength between male elite sprinters, sub-elite, and untrained controls. Once again, what were the three hip muscles consistently larger in the elite? Tensor fasciae latae, sartorius and gluteus maximus. I think this is straightforward, most of us understand the importance of the gluteus maximus, but looking at these hip flexors, we see how important they are.

What surprised me in this study was the plantarflexors showed no difference between sprint groups. That was surprising to me. Because we talk about the push-off, we talked about the importance of proper dorsiflexion and then during the ground contact, really go into a plantarflexion. I was surprised with that. Greater hip extensors and gluteus maximus volumes, they discriminate between the elite and sub-elite sprinters.

What can we do to possibly improve our performance a little bit? You know, technique? Well, leg drills, are looking at triple extension. We are looking at triple flexion drills. Just think for a second, the triple extension we can do that with clean and jerk, hang cleans, deadlifts. You can do some squat jumps. The triple flexion, once again, a little more difficult. I am working right now on some exercise protocols for triple flexion. I am not introducing it here because I am still playing with it.

I am a little bit like the mad scientist in there. Arm drills, very important, standing and seated, elbows locked, movement at the shoulders, the classical chin to pocket. When we talk about stride frequency, we see, a lot of times, stride frequency is dictated by arm swing frequency. Arms have got to stay relaxed.

Talking about speed. The acceleration, 10 to 40 meters, that is our acceleration point. Speed, you are going to hit top end speed at 40 to 70 meters. Even in soccer, let us say you have a back doing an overlap, all right? They are going to cover that 40 or 50 meters and then they have to cover the 40 or 50 meters to get back on defense. Then at speed endurance, that is where we are getting it to 80 to 150 meters. If I am working this as a session, if I am working just acceleration for a training session, I am going to go in that total volume range for a training session of 200 to 400 meters, no more than that. There is a lot of times I might just do 200 meters. I might just do 5, 40 meter sprints, and that could be the work out, maybe with a 4 or 5 minute gap in between, have them do a little bit of easy dynamic or ballistic stretching and timing them.

Let us say I have a football player who runs a 4.4. I want them to run a 4.4 for that first sprint and then I will let them rest 3 or 4 minutes. Let us say they are fourth sprint, they run a 4.9. No, that is too slow. I will just stop the work out there. Even though I had planned for 5 sprints, the fourth sprint was too slow, I will just end it. Or what if I find by their third sprint, maybe they are nursing an injury, I might end the workout with 3 sprints. For a top-end speed, I am probably going to be in that 400 to 600 meter range for total volume. I will not go more than that.

Let us say I am working 60 meters, I will do maybe 6 or 7 sprints tops for that training session. Speed endurance, I will probably go maybe as high as 600, 800 meters tops. Maybe I would do like 150 meters, I would do 550 meter sprints tops. In here, if we recap in the acceleration phase, I will do total training volume sessions of 200 to 400 for speed, 400 to 600 meter total volume. Then for speed endurance, a total volume of 600 to 800 meters.

Here is some of the breakdowns of where you are expanding your muscle energy. You can see almost 60% just to accelerate the body segments, and this would be the triple extension. A lot of that is a triple extension and then the recovery triple flexion. Twenty-two percent to decelerate body segments. We are talking about deceleration, how quickly can I go from deceleration to acceleration? The stronger I am in that amortization phase where I can- and that is where you do almost some of your eccentric work. The stronger I am there, the quicker I can get to the acceleration.

Three percent just to balance gravitational forces. This is interesting. If you are working with your athletes, you want to test single-leg balance, you want to see how they are in single-leg balance. A lot of times, I will have them standing. I will just have them drive up and see if they have a good balance with an explosive-type movement. You might have to put some time into single leg balance just so that when they land, they are not spending too much energy just balancing and taking away from the energy and their work to accelerate the body segment. Then there is 18% against air resistance and friction. Friction, we also mean ground friction.

The interaction of stride frequency and stride length. What is interesting is we want explosive horizontal push-off, but this is measured in vertical ground reaction forces. Even though we want as much ground reaction force vertically as possible, we want minimal vertical displacement. This is that horizontal where we want to work in that angle of maybe 45 to 60 degrees.

Your stance phase. As your leg touches down, the knees should be slightly flexed at approximately 170 degrees and your angle of alignment between your toe hip line, and horizontal line is approximately 60 to 70 degrees. This will vary from athlete to athlete, but this is what we are looking at. First of all, if we look at the toe hip line in here, follow that toe hip line, versus the horizontal line, you can see 60 to 70 degrees is where we want to be. When they are landing, we want to be at about 170 degrees of flexion.

What will happen is if this foot comes too far out and you are landing at 180 degrees, well, at that point, you are probably going to have to pull a little bit more. You are not getting as much push as you want. If you over-stride, what happens with a lot of people who over-stride, this hip will be further back in here, so they are landing and they are actually decelerating. They are losing too much energy during the deceleration phase, and that is sometimes, you will see people will talk about an athlete who is sitting down in their sprint. A lot of times, that is because they are over-striding.

Your flight phase. After you take off, the backward moving leg reaches maximal extension while your front leg is in an optimal flex position. When the back leg starts moving forward, the knee flexors should hold the leg folded at approximately 30 degrees. Through the propulsion phase, the athlete should bring the foot of the folded leg through the cycle at the same level of the supporting knee. What does that look like?

We can see 2 runners basically in here. You can see as that landing, about 170 degrees, he is landing in here, but this back leg, you can see it having almost a maximal extension, the back leg. Then we want to fold the knee. When you fold the knee and bring it in because the radius is smaller here, this is just physics, you can bring this recovery leg through quicker. Imagine someone who is jogging, going slowly, this recovery leg will be down here, which slows down the ability to swing that leg forward. If you look, you are doing a video analysis, look as to where this knee is coming through. It is coming through right about the height of the stance leg in there and then you are doing this. You will bring this leg through, and end up recovering and then go into your triple extension.

On that recovery phase almost maximal extension, you start bringing it through about 30 degrees of knee flexion in there to bring it through. The knee comes through at the height of the other knee, so it is not lagging, and that is almost perfect mechanics in there.

When you are talking about speed, define what you need to develop? You need to improve strength and power. Do you need more triple extension? Do you need more triple flexion? Your beginning athletes, you are going to need both, it does not matter. You want to improve your technique and then you want to emphasize the neural quality of that speed. That is what we talked about, you are training speed that session, that is all your training. If they slow down too much, forget it.

Boo Schexnayder once, he had an instance where a coach flew over from, I forget what country he flew over to watch a workout, he wants to see what Boo is doing. Boo had planned for 6 sprints, but his sprinters were pretty much maxed out at 3 and they were just too tired, and he ended the workout. The coach looked at him and says, "That is it?" He goes, "That is it for today. I apologize, but we cannot go any further." I think the visitor was a little disappointed. That is when we talk about, the emphasize of neural quality.

We are going to talk about agility a little bit. This is the ability to change direction rapidly. You can have anticipated movements and you can have unanticipated movements in response to an opponent, all right? Anticipated movements are during practice where, I throw the ball to you, you know it is coming and that is great and that is what you are reacting to your next move, but it is the unanticipated movements in response to an opponent that really become very important and training in an unpredictable manner. I think this is what a lot of athletes talk about when they say I am in shape, but I am not in game shape because they are not used to getting back into those unanticipated movements.

More terminology. Flexibility, the ability of a muscle or muscle group to lengthen passively through a range of motion. Mobility is the ability of a joint to move actively through a range of motion. Stiffness is a measure of how much load a tissue can take before it deforms. When we talk about stiffness, we are not talking about the everyday term, oh, I feel stiff today, the layman's term. No, we are not talking about that. We are talking about the ability of the muscle to stiffen and then react. Stiffness is good. When we talk about running, the athlete's ability, their ability to handle increased stiffness will increase their ability to produce force. That is what we are looking at.

I am going to show you a drill. Let us watch. This is a soccer player I remember as a child but let us watch his agility in here and let us watch this kick. The agility is his reaction to the ball. That is a nice kick, I want to break this down a little bit while we are doing it. I am going to stop the video right there. We think in terms of mobility and flexibility, look at his hips, there is nothing outrageous about the range of motion here. He is in a normal amount of flexion, he is in a normal amount of extension.

One of the things you notice is you are getting a lot of the leg movement, the hip movement. Why is he able to do this? Where does he get this great agility? From his core. His core is not moving, so his core is the anchor. His core is moving in space, but his core is acting as a stabilizing force so his hips can come through. Look at these hips, we are not talking about any excessive range of motion here.

On his follow through, the kicking leg, you can see once again, look at the flexion of the hip, it is not that extensive. What he is getting is he is getting great eccentric action here of the hamstrings, of the glutes so he does not go too far. Look at the core. We have some rotation, but we do not have any range of motion that you would say excessive. I mean, do you need to work flexibility in a lot of these cases? No, you need to work some mobility. He has the strength to maintain to follow through, but you can see that flexibility sometimes.

Look at the range of motion in here. Core is staying stable for his landing and the hips, nothing excessive about that. That is what we really want to work when we think in terms of agility.

This chart, is Young's work out of Australia where he broke down agility, and you can see it is based on perceptual and decision-making and then change of direction speed. With the change of direction speed, a lot of these things we can train, but perceptual and decision-making, a lot of that is a mental aspect. That is experience, that is some of our older athletes who are a little slower, they have lost a step, but they recognize events much quicker. They can react a little quicker even though they may not have the same muscular strength or the same speed.

When we look at change of direction, if you are looking at a shallow cutting angle or very quick, that is less than 250 milliseconds. That is what we would consider a plyometric. Sometimes, when someone is running full speed and it is aggressive cutting angle, they must drop down lower and that is going to be a bit longer and that is going to require more strength. We look at the orientation of the body. They must decelerate to a stop, leading into reacceleration. Increased muscle mass in combination with decreased percent body fat is regarded as the best predictor of change of direction ability.

If we look at the centre of mass here and we look at our centre of force application, if someone is cutting, all right, they are landing and planting, one of the things about is you want to keep this centre of mass. You want to make sure that it is just posterior to the centre of force application and then we want to rotate drive. One of the things about this is when we talk about core stability, if they were weak in the core in here, as they drop down, their centre of mass is going to keep going laterally, and that is when you become vulnerable to injury to the knee. That is where we see some of our non-contact injuries. They need great strength in here as well as strength in the leg.

The other thing is, if they are running at a very high speed, you need more knee bend. They must drop down lower, otherwise once again, their centre of mass is going to end up going lateral and that is where you are going to end up with an injury in there. We are looking at strength in the legs, we are looking at strength in the core muscles also.

Looking at this chart, we are working with agility. Here are some of the things that I can work with in terms of strength conditioning. When I talk about change of direction of speed, we can work on technique, we can work on straight sprinting speed, we can work on strength leg muscle qualities. Anthropometric, that is no change. We can do some technique, foot placement. We can do adjustments. You can see the things that you can do in terms of strength and conditioning. These others, you can also work with if you change some of the technique. This is playing as much as you can, but there are certain things you can do in terms of having them make decisions during their training sessions.

When we look at reaction time? We have pre-motor time, the time between stimulus identification and the onset of muscle activity. Then we have the actual motor time, the time between initial muscle activity and initiation of movement. This would include electromechanical delay. Pre-motor time, that is when you make the decision. The more experience you have, the more you have played, the pre-motor time goes down. If you do not have great strength or if you are aging, your motor time will increase. The pre-motor time can offset some of the decreases in motor time that we see with athletes as they get older.

In this slide we are looking at the central nervous system needing time to identify and implement appropriate postural and movement strategies to make decisions even before we move. Then the muscular system needs the strength necessary for executing these strategies as quickly and efficiently as possible.

Here are your stages of motor learning. First of all, the acquisition, what skills do the athletes need to know? The application, can the athlete successfully complete the skill? Assimilation, can the athlete do the skills and routines automatically? Adaptation, can the athlete do the skills and routines automatically in a unique situation?

I do not know if you have heard these terms before, but acquisition, a skill that the athlete needs to know. This could be at the beginning level. Sometimes, this is known as unconscious incompetence. They do not know what they do not know. Then you can teach them the skill, you are trying to apply it. They are not good at it, but they know what to do, so that would be a conscious incompetence. Then you want to see if they can assimilate. Did they get better at it? At that point, it becomes conscious

competence. We want to get to the adaptation where it is unconscious competence where they do not even have to think about what they are doing.

Here we have a W drill. He just goes back and forth in there. These are BlazePods which I got from the United Kingdom. This athlete has to make a decision. He must go to the light that goes off. I set up an easy one as a random type of drill, for filming purposes. I set up three, but you can set up six of these so that he has to make a lot more decisions. The whole idea is to really explode out of this.

This is a plank drill, which is an upper body reactive drill. She gets in a plank position; her shoulders stabilize as she has to react. Sometimes, the shoulder stabilizes and must react to the movement. Sometimes, the shoulder must move itself. It is constantly going back and forth between a stabilizing and a dynamic function. It is tough. That is the concept behind the agility.

We are going to get into plyometrics, and I am sure most of you are familiar with plyometrics to some extent. These are the exercises that enable a muscle to reach maximal strength in as short a time as possible. These exercises use the force of gravity to store energy in the elastic components of the muscle and then combine with the energy of the muscular contraction to exert maximal power. Plyometrics has also been called jump training and stretch-shortening exercises. You will hear the term of using the stretch-shortening cycle. Often, you will see the abbreviation SSC.

Depth jump versus drop jump. When we talk about plyometrics, there is a lot of confusion about what terms we are using. Not everybody agrees on the same terms. Some of this stems from the original research by Yuri Verkhoshansky because some of the people interpreted, they had to go to the original Russian manuscript. His daughter who has done some webinar, some seminars, she says that some of his work was misinterpreted, and she is trying to clarify some of the things that were done, depth jump versus the drop jump. Paavo Komi, he did a lot, once again, with the stretch-shortening cycle and the drop jump. Then Bosco did a lot with the drop jump test.

If you look at the initial depth jumps that Verkhoshansky talked about, this was with elite athletes, to increase explosive strength, very high drop heights and you had a pre-landing muscle activation. In the Russian translation, it was almost like he was calling these shock jumps. These would not to be used with beginning athletes. These were athletes who had a good amount of strength to begin with. A drop of 1.10 meters, that is a high drop. The drop jumps that Bosco worked with to improve elastic energy recoil, that drop height was 20 to 60 centimeters. You can see the difference in there.

If ground contact exceeds 0.25 seconds, then the power production can be significantly reduced. You may actually get more strength, but the power of value will go down. Let us look at some of the ground contact times. For sprinting, I mentioned this earlier, 80 to 90 milliseconds for ground contact time, which is a fast stretch-shortening cycle classification. With race walking, 270 to 300 milliseconds, which is slow. Some of the plyometrics, you might work, you can work slow in plyometrics. You can see, if you are working the depth jump, depending on how high it is and what the athlete's strength is, it could be anywhere from 130 to 300 milliseconds and then have multiple hurdle jumps.

What is interesting, when we talk about speed and contact time, we talked about 250 milliseconds. I work with some golfers, and when you look at their swing, the amount of time that they swing down, depending on how good they are, will be in that 200 to 300 millisecond range.

We do have what we call the reactive strength index, which is something you should be familiar with. It has been developed as a measure of explosive strength and it is derived by evaluating your jump height, divided by your ground contact time during the depth jump. You are going to use either a force platform or a jump mat. I use a jump mat for this and get some good values. Once again, your flight time divided by your ground contact time.

Your reactive strength index will give you a good idea of what level of plyometric you can work with when you are dealing with an athlete. When we look at a low reactive strength, you want to do just build up their strength, low-level plyometrics, moderate strength plyometrics, 1.5 to 2.0. You can see the values go up. When you get to world-class reactive strength ability, if that is greater than 3.0, you are probably working a lot of technique in just trying to maintain their strength.

We always talk about, well, how much strength do you need? There is a certain point where you probably do not need any more strength in certain athletes. For example, when you talk about doing a squat, for most athletes, for elite type strength, you want to get to two times body weight for this squat. If you start going more than two times body weight, we do not see much difference in performance or power development if you go much more than two times body weight. There is no need to keep packing on the pounds for your squat. We are doing that with other athletes too.

If you are looking at the reactive strength index test, you are jumping from a specific height. Here is what this shows. Here is a low drop height. You can see from 12 centimeters to 36 centimeters, the reactive strength index goes up. You can still work at this height, but look at this, the second athlete. When you go to 51 centimeters, their reactor strength index goes down and that is because they do not have the strength they need to handle this jump.

What is happening in this situation is when they jump down, they are spending a lot more time just taking the landing and they do not have as much energy to use the elasticity to increase and go for a higher vertical jump. Athlete 1, you can work them and still increase their power at a 51 centimeters drop. Athlete 2, no, you want to stay in this 36 centimeters range until they can develop enough strength and power where they can go up to the next level.

For the muscle spindle reflex to fire, you need a fast rate of eccentric muscle stretching. If you are doing low plyometrics, you are not really getting the benefit of the muscle spindle reflex, you are getting the benefit of elasticity of the connective tissue and you are getting the benefit of the elasticity of the tightening in the muscle and the elasticity of the tendon. For elastic energy, there must be a short transition period between eccentric and concentric phases.

For enhanced motor unit recruitment, there must be a fast eccentric phase and a short transition period between the eccentric and concentric phases. For increased force development, the eccentric phase must be slow. If you are looking at motor unit recruitment, if you are looking at elastic energy, it has got to be fast. If you are trying to develop a little more strength, then you are going to be a little bit slower in your eccentric phase.

Some of the program factors, we are looking at strength based. We will talk about this because these are some standards, but a lot of people do not go by this. For example, for strength base, you should not do plyometrics unless you can squat 1.5 times your body weight. We do not go by this. I would tell you, reactive strength index is just using a vertical jump, more importantly, because we have a lot of athletes who have never trained so they cannot even do a squat. Or you can have a tall or like your athlete who has great power, but they cannot squat.

I have had basketball players who cannot even squat half their body weight, but they have a 40-inch vertical jump. Well, if you have a 40-inch vertical jump, you have incredible power and you can do plyometrics. In fact, they developed this power because they are constantly jumping, so I don't use this. Upper body, they are talking about bench press 1 times body weight or if you can do 5 clap push-ups. This is interesting because it is very hard to do upper body plyometrics. The main reason being is with the upper body, the contact time is so slow.

I talked to you about 250 milliseconds as being the cutoff. Well, if you do a clap push-up, that contact time is going to be maybe 750 milliseconds, 800, almost close to a second of contact time. That is not really a plyometric at that point. It is not that you are not going to get benefit from it, but the elasticity you are getting from it is not from the stretch-shortening cycle. I think this is probably the best way of doing it. At least if you want to talk about plyometrics, talking about drop height, you select a drop height as low as 20 centimeters, you have them jump down, so I would do a vertical.

If you do not have any fancy equipment, you put some chalk on the athlete's fingers, you have them stand next to a wall and bring their arm up, have them raise their arm as high as possible and touch the wall and you can see what their height is. Then you have them do a vertical jump and you can measure the difference between chalk marks and you now know what their vertical jump is. Then you have them stand on a platform, 20 centimeters, and once again have them jump again with a little bit of chalk on their finger and you see what their vertical jump is. Their vertical jump should be higher than it is from just a standing counter-movement jump.

You can go to the next jump. From 20 centimeters, you can go to 30 centimeters, all right? At 30 centimeters, the vertical jump should still be higher. If you go to 40 centimeters and now, the vertical jump is lower, you know that is too high of a jumping height to go from and you bring it back down to 30 centimeters. That would be the easiest way of doing it.

If the drop height is too high for the athlete's strength, ground contact time will increase. They are going to be bilateral differences in peak force and average force based on drop jump height. We will see these bilateral differences in 20 and 40 centimeters, and this is done off a force plate, but once you start going to the real high starting heights, you will not see a bilateral difference but you will see a decrease in power.

Keep in mind, and I will talk about inches, is when we talk about vertical jump, there is a certain inhibition when we talk about a bilateral jump. If I am working with an athlete, I might find that if I do a single leg vertical jump on that left leg, it might be 17 inches. Then if I do the right leg, it might be 16 inches. Well, if I do a bilateral jump, countermove jump, I do not add up the 17 and 16 to figure out what their height will be. It will not be 33. In fact, it will probably be about 26 or 27 inches. When you do a bilateral jump, there is a certain inhibition that one leg crosses in the other leg as opposed to a single leg vertical jump.

When we look at plyometrics, what equipment are we using? Footwear, surface, facilities. You want good footwear, although some people will do this barefoot, but make sure the athlete is used to working barefoot before you do it. The surface has some give but not too much. If there is too much give, you cannot get a jump because the surface is absorbing all the force and the contact time becomes too long. If the surface is too hard, you can start getting injuries. Then just proper facilities. Do they have enough space to do some of these jumps, some of these sprints? Is this a safe facility? Just your basic precautions.

When I talk about some of the movements, if you go to different seminars, different instructors will talk about different type of movements. Your jumps are basically triple extension type movements. When we talk about hops and this could be single leg or double leg, this is the paw mechanics and this is more about pushing off. Hitting the ground clawing the ground and pushing off, whereas your bounds are more about push mechanics. That could be more of in a horizontal manner or more of a vertical manner.

What do I want to do in terms of intensity, this is a system I use. Level 1 plyometrics is eccentrics. This is all about the landing mechanics. Remember, I talked to you about deceleration. A lot of this is landing. I want to see first, I just emphasize, can the athlete land? Just have them stop, minimal flexion of knees and hips and then stick it. As I increase the amount of force, then I want to increase the amount of flexion at the knees and the hips for the whole concept is stick the landing quietly as they are developing their

strength. The more they develop their strength, the more I know they can now convert that eccentric into a concentric action in terms of acceleration. The level 1 plyometrics is all about developing deceleration.

Your level 2 plyometrics, low-intensity. You are minimizing ground contact. The jump height is unimportant. Ankling, skipping, this is all about creating just quick motion, creating stiffness in the leg, staying on the balls of the feet. Jumping rope, jumping rope for 20 seconds is an excellent low level plyometric.

Then your level 3. This is where you start increasing intensity. This is where you are minimizing your ground contact, maximizing your force. You are talking about your horizontal and/or your vertical jumps. This is where we start getting these are your depth jumps, these are your drop jumps. Going from lower intensity to higher intensity, your jumps in place, just easy jumps then you are standing jumps now. You can start doing broad jumps, you can just start doing vertical jumps. Then you start combining them. Multiple hops, multiple jumps. Then you go into your bound exercises and then you start your box drills.

You can now stand on a box and jump down, or you can stand and jump onto a box. Out of the two jumps on a box, jumping onto a box or jumping off a box, which is the lower intensity one, you are safer if you jump onto a box. The reason is when you jump onto a box, gravity is trying to pull you down as you land, so you are just starting to decelerate so your contact forces are not as high as if you are jumping off a box and you are getting all your gravity acceleration involved. If I am just starting with an athlete, I might have them for explosive jumps, just jump onto a low box. Then you start getting to your depth jumps where you are jumping off the box and then trying to explode out of that.

If we look at program design, let us look at the frequency. Well, you know what, this is a high intensity type exercise, so you really do not do much more than two days a week. Here is your volume. When we talk about volume, this is foot contacts. Your beginner foot contacts, not more than 80 to 100 contacts for a session. If you are doing an exercise, let us say you are doing some bounding exercise, some skips and you are doing 8 repetitions, that would be one rep. Well, if you do six of those, you are really at low almost like 48-foot context at that point, so you are only doing two drills.

Your intermediate, 100 to 120, although I have seen ranges of 100-to-150-foot contacts. Then your advanced, 120 to 140 and you are going up to 150 to 250 contacts. When I say a foot contact, if you are doing a single leg hop, that is a foot contact. If you are doing a double leg hop, that is still only one considered one foot contact. Where I find it interesting, this is where I have worked with some volleyball teams is sometimes, in their warm-ups, I watch them during warm-ups before they get into their plyometrics. Their warm-ups, they might be doing almost 50 to 100 jumps even before the warm-up, same thing with the game. I am amazed at how many jumps a volleyball player will take in warm-ups before a game. They are almost taking 150 to 200 jumps even before the game starts. I have spoken to some volleyball players where I really think that needs to be downplayed that we need to decrease the amount of jumps they are doing in their warm-ups.

Then we look at the intensity. Once again, we went over the different intensity. Recovery progressive overload. When you are talking about that progressive overload, how much recovery are they getting? You want one or two days. Also, if they are playing a game, what do you do next the next day? Do you want them doing plyometrics or you want that recovery? That is how we deal with, when do you want to do these types of workouts? A lot of this is done more preseason than in season, but then it becomes a case.

Let us say you are dealing with a soccer team; do you want to do these plyometrics sprint? It really depends on who that player is. When we work with basketball teams, a lot of times, basketball teams have an 8-man rotation or 8-woman rotation, so the 9th, 10th, 11th player, they are not getting as much

work. Whereas, your starters, those players are doing a lot of jumps, a lot of sprints, so they need more recovery. You may almost need 2 different workouts depending on how much playing time that player got in season. Then we like to combine our plyometrics and weight training.

This is interesting for children should children do plyometrics. First, if you look at child, you do not have an option. Children are always playing around with jumps and so they are doing it anyway. In fact, for most children, they are safer if there are no adults involved when they just can jump and play on their own. This was an interesting workout. This was done at a soccer academy, aged 8 to 14. The current evidence suggests that a program of twice per week at 50 to 60 jump sessions for 8 to 10 weeks results in the largest changes in running and jumping performance. That you actually can get some benefits if you do a little bit more of a guided program.

The plyometric training had a large effect on improving the ability to jump. The effects on running velocity were not as consistent across the studies. Looking at the studies, I think a lot of that had to do with the type of plyometrics they were doing. They were doing plyometrics that emphasize the vertical and not so much the horizontal. An example of this would be if you are doing a lot of vertical jumps as opposed to broad jumps, if you want to develop more horizontal type of ability, then you are going to do bounds and emphasize more of the horizontal length as opposed to the vertical length. There was some improvement in their agility and their kicking distance in the soccer players, and each study did address safety in a satisfactory manner.

The focus of the exercise should be specific to your desired outcome. Progression should be to 90 to 100 jumps by the end of the 10 weeks. That is what they found. They were starting at 20 to 30 and progressing to 90 to 100. Sessions were 10 to 25 minutes in duration. They had warm up, they had cool down. The drills last approximately 10 seconds. No matter what drill you are doing, it should only last 10 seconds. It was a 90 second rest between drills.

They also found that when you are doing these drills, there should be a low instructor-to-student ratio, 1:4-5. This is where the assistant coach has become very important and the assistant coaches who know what they are doing. In the States, we have a lot of these soccer programs. We may have one coach and maybe an assistant coach who knows what they are doing. Then you have 2 or 3 parent volunteers who probably do not have much of a concept. They think they do, but they really do not have much of a concept.

This was interesting is, how can you sequence the effects of balance and plyometric training? I talked about balance and how important it is that they have good balance strength so they do not waste too much time or energy when they land so that they can start converting that into a concentric action and increase power. This was an interesting study that they did.

They want to see what the effect of sequencing balance and plyometric training on the performance of 12- to 13-year-old athletes would be like. Twenty-four young elite soccer players train twice per week for 8 weeks, and they changed it. One group for the first 4 weeks did balance training followed by plyometric training. One group did 4 weeks of plyometric training followed by 4 weeks of balance training. I included the workout in case you want to see that. I thought it was a fascinating study. I thought it was well laid out.

You can see what jumps they were doing, and you can see what their workouts were. You can see some of the higher intensity type of plyometrics single leg maximal rebounding, drop jumping from low platform, performing ballistic type push-ups. You can see that was included later in the training session. They work out 6 workouts, 7 workouts, 8.

What they found was that sequencing the 4 weeks of balance plyometric training in the 12 to 13 elite soccer players resulted in either similar or superior performance enhancements compared with plyometric before balance training. If you are not sure about what level your athletes are, I emphasize, get them started on balance training first, develop their strength in a balanced position. This would be doing stick it, just maybe some simple hops and then go into more of your plyometric training the following 4 weeks. If you are working preseason, you start your drills, you start your team drills, you start all your individual skills, work your balance training into those sessions before you start your team sessions, and then 4 weeks after that, then you can start going into more of your plyometric training.

When we are designing a program for athletes, we have all these concepts: speed, agility, strength training. What do we do with it? Well, let us look at a needs analysis. Before you do any program design, what is a needs analysis? This helps determine the current state of the athlete and what level that athlete wants to achieve, that is their need. You look at the task analysis and this involves the sport. For example, from a metabolic stay point of view, what do they need? Do they need more speed, more endurance?

From a skill point of view, what strength do they need? What do they need in terms of the game itself? Then you look at your athlete analysis. Well, the athlete you are dealing with. If you look at that, you can see you might have a team, but your athletes are in a different position. We often train teams all in the same manner. Sometimes, we do not have time to do individual programs, but it is individual programs that we need. What are your goals and priorities? Not only of you but of that athlete.

I worked with a golfer in the PGA, and clearly, when you talk about his goals, what are his goals, well, he wants to be able to finish the season without being hurt and he wants to be a top ten golfer. He wants to be one of the top 10 golfers in the world. What are your resources and your constraints? What do you have available? What are some of the constraints of the training?

If I am working with a PGA golfer, I may want them to train, but if he has a term and he is doing well, he is playing Thursday, Friday, Saturday, Sunday, Monday is a travel day, maybe we can do some strength training there. Tuesday, he is already starting to practice. Wednesday, if I gave him too much strength, it could mess him up for Thursday's first round. How do you work around that? In this case, Monday usually a travel day. He usually gets in and he can do a strength workout. Then Tuesday, he can practice, he can do some flexibility. Then Wednesday, he will do strength, but what we do is it is high-intensity low-volume so we do not tire him out the Thursday. That is what I mean when we talk about resources and constraints.

Let us look at soccer for a second. Let us look at some of the task analysis. Less than 2% of the total distance is with the ball, which means when you do have the ball, you have got to be very good with it. I notice when I watch EPL versus watching college soccer in the States, that is the big difference. You see a lot of the American college players, they are in great shape. You will hear the announcers like, "What a motor on that athlete. Look at him go after the ball." Well, the reason he is going after the ball working so hard is because his first touch is so poor. You work on the EPL, they make it look effortless, like that first touch is so good. They are doing a lot of action, but they can really focus more, when do they need that burst of speed? When do they need that follow-up or when they have to chase someone down?

One to two thousand bouts of different action. Activity transitions every 5 to 6 seconds, 3-second rest every 2 minutes. Their sprints have a 15-meter average. About once every 90 seconds, they might break into a sprint. But once again, that could be clusters too. We talked about clusters of time. I can tell you, well, every 90 seconds, they must do a sprint. Does that mean I have them sprint for 15 seconds and then their rest period is 90 seconds when I train them?

But we also see clusters and we see different time where they may have a cluster where the team is attacking, and they may sprint and only have a 10-second rest in sprint and 10-second rest in... They may

have 3 or 4 sprints in a row and then they may not sprint. Maybe the other team takes over them more in a defensive shell and maybe they have a 15, 20 minutes where they are not hardly doing any sprint. We must be careful. We just talked about averages that sometimes does not consider the actual run of play of a game.

Standing, 17%, walking, 40%, easy running, 35% of the time, easy running backwards, only about 2% of the time, and then hard running, 8% of the time. Typically, in a soccer game, in an EPL game, maybe they are going a total of 10 kilometers per game. That is a pretty good distance, but how much of that is sprint? You want to break up. That is what we mean about needs analysis. How do you break up a sport? If I am dealing with American football, a play only takes 5 seconds, a lineman, the most they are going to do, they are basically going to explode out of a stance. Maybe the play lasts 5 or 6 seconds and they are going to have a 35-second rest, assuming they are not being subbed out of the game for another lineman.

When you look in this analysis, a lot of it is design test protocol, so we know where the athlete is. We look at our administration of tests. What is this? We must supervise these tests. We must make sure they are warmed up. Then what is the motivation? Are you truly getting excellent results in terms of motivation and are you safely administering the test? The last thing you want to do is hurt an athlete during a test. You do not want to be the coach or the health care provider who hurts an athlete during a test.

I have run into some things with motivation. I have seen great players and you time them on the 40-yard dash, and you know what, their time is like 4.6 or 4.7. It is not even very good, but if you watch game, no one can catch them. The difference is motivation. They just do not care that much during a testing procedure unless they are a rookie coming in and must worry about their spot on the team. That is great motivation.

These are the different categories when we are looking at test selection. If you just look at these quickly, you must decide which of these you want to test. For example, local muscular endurance, do you really need that for your team? How many tests do you want to do? When do you want to do them? Are they being done preseason? Are you doing this to select the team? There are several different choices you must make.

Here are some things for local muscular endurance. You can do curl-ups, you can do push-ups, abdominal endurance, back extensor endurance, lateral trunk endurance. I am not sure how vital these are. For example, a lot of the sports I deal will... Even a soccer player, they are resting. They need more explosive movements, so their core strength is more about exploding-relaxing, exploding-relaxing. It is not about keeping the abdominals tight. Let us say you had a fighter like an ultimate fighter where they were going 4 or 5 rounds or a wrestler where they must keep a certain amount of stiffness for extended periods of time, then you might want to know this type of thing. This is a category that is there that I generally am not using.

Strength and power. You can do one rep max bench press, squat, one rep max power clean. This can be useful for an athlete who is lifting, but do you want to do this in a rookie camp or someone who is not used to lifting or a sport that is not used to lifting? No, I do not think you need that. You are not really going to get a good determination. However, for lower body, you can get great determination with a vertical jump. You can get a great idea of what their power is with the standing long jump. If I am working with a sport that is traditionally not weightlifting or athletes who have not been weightlifting, this is what I want to do. If you want to measure upper body power, there is several different medicine ball throws that you can use.

I am waiting for it to come out on the market right now, but there is a company that is developing a medicine ball with an accelerometer built into the medicine ball, so you can do a horizontal throw. I like the chest throw where I have them lean against the wall and just throw for horizontal power. I know some coaches who like where they are standing, and they are doing a rotational throw for power. You decide, but then you just want to standardize how you are going to do it for the athletes.

Aerobic capacity, a 1.5 mile run or a 12-minute run. You can go by distance. There is some correlation with aerobic capacity and how well they do. I would do this more for a non-steady state. It might be good for a basketball player or soccer player. I think this is a measure you would probably want more, anaerobic capacity, because they are non-steady state, the ability to sprint-relax, sprint-relax. I think in a basketball player, the anaerobic capacity becomes more important and then the soccer play, the aerobic capacity might be a little more important.

I would tell you when I am training soccer players and want to develop this capacity more where I might have them do a total of a mile and a half or two miles or even go three miles, but it would be based on a 50-meter sprint, 150 meter jog, a 50 meter sprint, a 150 meter jog to get up to 3 miles. I think this is a staple. I like to keep it in there, but I am not sure how I feel about it.

Agility, I think this is great. We use a T-test, we use a pro agility test which I think is great. These are short tests. I want to know what their agility is because if they do not have great agility, I have an idea of where I need to build up their strength. Then the speed, the 40-yard sprint or the 40-meter sprint. I think this is a good evaluation. I think speed is just so necessary. I think speed is what divides one level of player from the next level of player.

In the United States, we really work on the 40-yard sprint. There are cams just for the 40-yard sprint. You have a lot of college players who go to these combines and in their position on a team where their draft position will be based on how fast they can do a 40-yard sprint. A lot of this is the drive. The initial segment lasts 7 steps, explode. I mentioned this before, stay low at 45 degrees. If you want to train them for speed and you want to add a little bit of power, what would you do? This is where you can do the sled push, but it has got to be a weight where one, they are staying at 45 degrees and two, they are not slowing by more than 10% of their actual time.

Transition, that is where you are going from that 45 degree into a more upright position that takes about 2 seconds and then finish running through the finish. The best is John Ross. In 2017, he ran a 4.22. Is John Ross playing in the NFL? He ran this in 2017. As a matter of fact, he has had some injuries. If you do follow American football, you are not thinking of John Ross when you think of great receivers. That is what we must look at with players. No matter what your sport, it is not the person who is the fastest player, it is not the person who is the strongest player, who is going to be at the top, but they do need minimums.

If you look at your top soccer and you look at your top rugby players, there may be other players faster, but they are still fast. It is just their skill level is higher. Same thing if you look at your locks, your props. If you look at during rugby, well, they need a certain amount of strength. They may not be the strongest man in the world, but they certainly have a certain amount of strength combined with their skill.

Then you can look at body composition. This is just to get a basic idea. You can see I put a star next to some of these, when we talk about hydrostatic weighing which is the gold standard. I do not know what you are using, what you have available to you. Hydrostatic weighing measures the mass per unit of volume. Percentage of body fat is estimated based on the density of the body. You must account for residual volume in the lungs, how much air there is. You can use the Siri and Brozek equation.

So much of what we do with body composition is based on equations, and these equations come out of books. humankinetics.com, if you are looking for specific values, let us say you want to use a treadmill protocol for aerobic capacity, go to humankinetics.com and get their book. I know they have a European office also, I think, in the UK. humakinetics.com would give you a lot of information on that. I have no association with humankinetics.com. One of those conflicts of interest, just the fact that I like a lot of their publications.

Here is what you must do. One, you must make sure the athlete is comfortable being underwater. This is not a very feasible type of testing situation. First, these tanks cost a lot of money. This is something that you are going to find more on a university setting for research.

Hydrostatic weighing may overestimate body fat percent in elderly patients. There may be an underestimation of body fat percent in athletes due to denser bones and muscles. I have seen 1 or 2 athletes in hydrostatic weighing tested as negative percent body fat, meaning they did not have any body fat, which we know is impossible. That is based on certain assumptions.

Most body fat estimation techniques are based on a two-compartment model. You either have fat or you have fat-free mass, but the fat-free mass includes organs, muscle, bone, and body water. The fat-free mass does not necessarily equate to muscle. It is possible, based on their bone, how much water they are carrying in their body. It could be read as fat-free mass and give you an inadequate or it actually- and inefficient measure of how much muscle they have.

Skin fold measurements. I think this is a great basic concept. Based on the relationship between subcutaneous fat and total body fat. You can use a combination of 7 different sites. Once again, this is based on equations measured against normal. For example, Jackson and Pollock. Where do you get these equations? Once again, you get them right out of a book. I use a book that I got from humankinetics.com. This can be up to 98% accurate, but the accuracy is based on the tests or who is using it, someone who has done a lot of testing who is used to it.

If you are going to do subcutaneous fat skin fold measurements on your team, the person who does initial measurements should also be the person who does follow-up measurements because you are going to lose some reliability if you change the tester. I use a lung caliper, very accurate. I have used it for years and not very expensive, a few hundred dollars and you can get some very good readings.

This is the Bod Pod which is something you will see more of in some high-end corporate fitness centres or in academic settings for research. It is the same concept as the hydrostatic weighing where you are displacing air instead of water. That is how they are doing it. This is a very expensive piece of equipment. I think this in US dollars is maybe USD 31,000, USD 32,000. I just want you to be aware that it is out there. I have tried it. I have been to at the conference where I have tried it. It is interesting to use, but a lot of money for something you can get pretty accurately with skin calipers.

Body composition. The body mass index which they are using also just based on your body mass and your stature and it will give you different levels. You can see the limitations of body mass index. I would not use it, especially with athletes, athletes are just off the curve. What is interesting is body mass index is basically a rehash of some of the actuarial tables used by insurance companies in the 60s and 70s. When I did my master's program and exercised physiology in the early 80s, the body mass index has actually been eliminated. I do not know who decided to bring it back.

What really bothers me the most about body mass index is it is in a lot of the electronic health records in the States. It almost gives you an official value, so you can have someone in great shape and they may end up with a high body mass index as overweight or even obese, which is not an indication of their actual fitness levels.

Test selection. Body composition, hydrostatic weighing, skinfold. I would go with skinfold measurements. Flexibility. This is one of those things. I do not even test for flexibility, to be honest with you. I do certain motions like I will do a lunge to see if it looks like they have good hip flexibility in there.

I might do a Thomas test, but I do not actually test. I almost feel like flexibility, how do you define it? What is a good flexibility? What is not? It is almost like jazz, you either know it looks good or it does not look good. I do not use flexibility test when I am doing any preseason with athletes, pre-season testing.

In the United States, this was a Division 3 college soccer team and how they did their test selection. This was a good school, it is not great, it is not Division 1, which is the highest level in the United States, at the University level. This is good competition soccer, and I worked with this team. When they do their test selection, it is a 3-day, so they are in preseason camp. This is before the semester is starting, they are getting ready for the season. They have their returning players and then they have the new players who are trying to make the team.

On Day 1, they expect their players to do a 2-mile run under 12 minutes under a 6-minute mile. Then Day 1, this is done, they warm up, they do this in the morning and then they will have a team session, so after the 2-mile run, they will have 2 or 3 team sessions. A lot of times, test selection is included in their camp in terms of team training.

Day 2, they will do a shuttle sprint, which is more for agility and more a little bit of anaerobic testing. They do a 60-second sit-up test and a 60 second push-up test. am not crazy about it, they like it because it is safer than doing any strength testings.

Let us go back to Day 1 for a second, 2-mile run the players have to do under 12 minutes. I asked a player, "Well, what if you do not do it under 12 minutes?" he says it depends on who you are. If you are a starter returning from last year and you are a great strike, it does not matter. If you are trying to make the team and you are not in shape, that is usually an indication that they are not going to take you. Day 3, they do a vertical jump. This is what I talked about for power and they do a bench press. They only do lifting, but they did a squat test as well, but only for returning players because they know their returning players have been trained how to lift correctly. It also gives them an indication of which of their players kept training offseason. They will not do this for first-year players who are coming out of high school because they are not sure how they were trained.

So you have an idea of how you might do some of your program design. I want to throw in just something on environmental stresses. This will be brief. Hypothermia, defined as a condition where the core temperature is 95 Fahrenheit or 35 Centigrade. Muscular coordination becomes affected, judgment is impaired as core temperature decreases.

This is something we have here living in the United States in Minnesota. The temperature is about 5 degrees Fahrenheit, almost zero degrees. We can see, so we play outside. People are skiing. Hypothermia, sometimes, you build up your core temperature, so you are not really being affected by hypothermia. If you get tired, if you get fatigued, your muscular coordination will become impaired, but even more importantly, your cognitive ability.

Your judgment will also become impaired, which is when people run into trouble. Whether we talk about people who are going on Mount Everest climbs and things like that, they start making poor decisions. I remember reading one of the tragedies, I wish I could remember what year it was, with Mount Everest, where one of the things they found is one of the climbers died near an oxygen tank that had oxygen, and they think that he misread what the gauge said so he did not even bother with the oxygen tank.

We have our wind chill index. This is wind constantly replaces the insulating air around the body with cooler ambient air. For example, once again, in your cold weather. For example, we are at 5 degrees

Fahrenheit today, where the wind chill, it is about minus 6. It is a little misleading because a lot of times, the wind chill index is almost based on well, what would it be if you were not wearing any clothes? Since I do not know anyone who really goes out without clothes in this type of weather, it is a little misleading.

Respiratory check when we are talking about environmental stresses. In extreme cold, incoming air is warmed between 26.5 and 32.2 Centigrade by the time it reaches the bronchi. In a very cold weather, if you wear some sort of scarf or mask, you can also warm the air a little bit more so that this is not as big an issue. You are still getting the air at the proper temperature as you inhale and it gets into the body.

Altitude stress, is a little more interesting. High altitude decreased barometric pressure reduces the ambient pressure of O2. Acclimatization, dealing with reduced loading of hemoglobin. Immediate changes, you get hyperventilation, increased blood flow from increased submaximal heart rate. It takes about 2 weeks to acclimatize at 10,000 feet. What I find interesting about that is I have patients who go on ski weekends, so we are pretty sea level. They will go, and you need 2 weeks for acclimatization, and they are not getting it. They do everything possibly. They will ski all day and they are not used to working at that height. Then they will drink all night, so they get dehydrated. They almost do everything that you could possibly do to be wrong and to hurt the body for a ski trip.

Here are some of the hematological changes you will see: decreased plasma volume, increased hematocrit, increased hemoglobin, and increased number of red blood cells. This is where the acclimatization, some of the things that we will see. Decreased plasma volume, you must make sure you hydrate under these conditions. I think that is one of the biggest mistakes athletes make.

This is a concept that is being used, live high-train low model. The training method is the athletes live at high altitude, but they train at low altitude. Their goal is to improve performance at sea level and they are trying to get these modifications living in a high level. You are trying to get that high altitude acclimatization, but you maintain the intensity of low altitude training. If you go at high level and you are not used to training at a high altitude, you cannot train as intensely, so you can lose some of your training ability. That is why they live high, but they train at a low level to maintain the intensity of their training.

You see an increased erythropoietin activity. This has not been observed in simulated live high-train low models. For example, hypoxic tents, and I have seen different research on it. It varies. It is a little contradictory, but I would have to say most of the research tells me that these hypoxic tents are not working, that you may have some changes if you have a hyperbaric chamber, but most of our athletes do not have access to that.

Here are some of the related medical problems: acute mountain sickness. You can see a lot of people; this is something that is not that uncommon. You are not used to being at high altitudes, headaches, dizziness, nausea, constipation, vomiting, some visual problems, general weakness. It can occur within 4 to 12 hours of 10,000 feet. Appetite suppression can be severe, symptoms are gone within one week, so this would not be uncommon for some people. A lot of people do not have this. I do not want to give you a specific percentage. Ten percent would not surprise me.

Some people can suffer from high altitude pulmonary edema. General fatigue, coughing, headaches, nausea, this will occur in 2% of the population within 12 to 96 hours after they go to a high altitude. This is life-threatening. If someone has these symptoms, they must get down right away, they cannot play with this. They cannot wait to acclimatize, this is life-threatening, and you want to get them down there. I also would recommend at this point that they just do not go down on their own. I think someone must go down with them because once again, with these types of symptoms, you do not know when it can all of a sudden escalate.

You can have high-altitude cerebral edema, more severe than a pulmonary edema. This is cerebral vasodilation occurring with increasing edema that distorts the brain structures, occurs in 1% of the population. They must be taken down immediately. The symptoms would be just more severe type symptoms than pulmonary edema, severe headaches. Get them down immediately, not on their own, as they have to be able to be transported right away.

When we look at some of the related medical problems, at 1,500 feet, 457 meters, you will start getting a decrease in light sensitivity. At 3,000 feet, you get a decrease in light sensitivity, you get a decrease in visual acuity, you do not see things as well. I put in Denver. In the States, this is known as the mile-high city, 1,610 meters. We have several professional teams who go to play there. For example, we have basketball, we have football, we have hockey, so visiting teams who might be sea-level teams have to go to Denver. With this type of altitude, a 33% decrease in postural stability, a 15% decrease in cognitive ability, and a 20% decrease in recall ability.

Typically, a lot of football teams, if they have a Sunday game, will fly in on Friday. You know what, that is not enough time to acclimatize, but it is enough time to start feeling some of these deficiencies. That is why you will find a lot of teams where they will go in and they will go in as late as possible. They have a Sunday game; they are going in maybe Saturday afternoon. They are doing all their pregame workouts at their home field and then going to Denver. If they have a Monday night game, they are not flying into Denver till maybe late Sunday or early Monday. They are trying to offset these effects that they would feel from acclimatization. Where you run into trouble, let us say you are a hockey team in the playoffs who are going to play the Denver Avalanche, well, you have 2 games in a 4-day period which means you can fly in as late as you want for that first game, but you are going to get hit by that second game.

[END]