Exercise Physiology- Part 7

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It is the cardiorespiratory physiology. We're going to talk about pulmonary function. We want to talk about cardiac function. And at the same time, besides, just go over specific values. How does it affect us?

We don't do a lot of cardiac evaluation of pulmonary function in our office. What do we need to know? What are the basics we need to know for some of the exercise and for some of the athletes?

So these are some of the static lung volumes. And I gave you the values in your notes. So you can see what they are. So you don't have to really copy anything down.

But some of the basics. Tidal volume. Tidal volume is your basic resting breath.

You breathe in, you breathe out. For most people, as you can see, it's about 1/2 a liter per minute-- 1/2 a liter per breath, my mistake. And that is your basic breath in.

Something like inspiratory reserve volume would be if you took a tidal breath in, how much more can you inspire after that? So here's my normal inhalation. And then if I try and inhale after that, that would be the inspiratory reserve volume. And expiratory reserve volume is the same concept, after you have a normal breath out.

Residual volume, this is a term you want to know. This is the amount of air in your lungs that you cannot get out. The residual volumes stay. So if you do, for example, if you do body composition and you do underwater weighing, you have to take into account the residual volume, the air in your lungs. And this is taken into account with the equations when they do underwater weighing-- the hydrostatic weighing.

The functional residual capacity, that's just a combination of the expiratory and the inspiratory reserve volume. The forced vital capacity. And this is a term, this is after you inhale, how much can you exhale as forcefully as possible? So this is after the inhalation, how much can you forcefully exhale? And we'll see why this becomes a little bit more important in a minute.

And then your total lung capacity, which would be your forced vital capacity and your residual volume. So when you do your forced vital capacity, you're breathing in as much as you can and breathing out as much as you can. That's the forced vital capacity, all the air you breathe out. But you still have that residual volume you can't get out. So that would be your total lung capacity.

So these are all static volumes, OK? When we talk about athletes or when we talk about performance, or just a function, we really have to look at dynamic values. So the first dynamic value we'll look at is FEV-- the forced expiratory volume-- against the forced vital capacity ratio.

Now once again, the forced vital capacity, that says you take a breath in as deep as you can and you breathe out as much as you can. That's the forced vital capacity. The forced exploratory volume is how much of that forced vital capacity can you get out in one second. Generally, most people can get about 85% out in one second.

Someone who has maybe a chronic obstructive disease, or asthma, they might be able to get out 85% but it could take four or five seconds. So the static volumes could almost measure the same. But the dynamic volume would be different. And when we talk about exercise, we talk about performance, we know it's the dynamic volume that matters.

Maximum voluntary ventilation. How much can someone actually breathe in a minute? Well, you can't have them breathe as hard and as deep as they can-- in a minute, they'd pass out. All right? So with the maximum voluntary ventilation, we see how much they can breathe in as fast and as deep as they can for 15 seconds, and then we extrapolate.

So it is a 15-second test. If you've never done it before, it can still be quite exhilarating. But it would make you a little bit dizzy.

Now under the maximum voluntary ventilation, generally, you're getting 30 to 40 times what you would get in your forced expiratory volume. For a typical male, this would be 140 to 180 liters per minute. Female would be about 80 to 120 liters per minute.

If you're looking at some elite athletes-- for example, your Nordic skiers-- they can get about 190. And I think the high was about 239 liters per minute. This is a lot of air.

If you can imagine almost like a liter bottle of water. And now imagine 240 of those liter bottles. And that's the amount of air going in and out of the lungs in one minute. It kind of points to the fact that maybe pulmonary function is not a limiting factor in performance or exercise-- at least the mechanical ability to get air in and out.

Minute ventilation. This is your tidal volume times your breathing frequency. So tidal volume, once again, if we're talking about someone in normal resting breath-- of about 1/2 a liter-- times breathing frequency-- maybe about 14 to 16 breaths-- so we're looking about 7 to 8 liters of air we breathe in at rest, just in and out.

OK, now those are some of the basics of pulmonary function. And for a chiropractic clinical practice, we really don't need much more than that. So what I want to focus is, when we talk about the lung volumes, I want to really talk a little bit more about asthma because this is something we're more likely to see. So if we talk about pulmonary function and how it would affect us clinically, well, we don't really do much.

When we talk about people, our patients with COPD, we're not really doing anything in terms of exercise. That's tough to do. We're doing some adjusting to help them with the tightness they have in the upper thoracic region, the cervical region. But maybe not as much with the pulmonary, with the exercise. Asthma is something we see.

Now something that's been in the research has been what we call the refractory period. The refractory period is a period of submaximal exercise that may decrease asthmatic symptoms. And what this is, is sometimes, if you have your athlete-- let's say they have a 2 o'clock event-- if they begin exercising at 1:30, submaximally, for about 10 to 15 minutes and then rest, it seems to decrease some of the asthmatic symptoms that they might have.

Where this can really come into play-- where I've seen it come into play with certain athletes-- would be hockey players who have trouble in the cold air, especially after periods of Zamboni has been on the ice. So what they can do is, before they go back on the ice, they'll all be in the locker room, maybe do a little bit of bike riding-- stationary bike-- submaximal riding. I've seen it with some runners who know when they go out in the cold air, besides the exercise-induced asthma, they have some of the, just the typical asthma symptoms. They may do, in a heated area, about 15 minutes of submaximal exercise, rest for 10 or 15 minutes, stretch, and then go and do their exercise. They also seem to have a decrease-- a diminishing-- of the symptoms with asthma.

OK. So we have the refractory period. We also need to look at-- when we're looking at pulmonary function-- for more of a functional view, what are some of the muscles that we need to focus in on? People who are having trouble with their breathing.

And one of the problems with the asthma is the reliance on the accessory inspiratory muscles, that they're always breathing from the chest. And that's the problem. So these are the muscles that we're going to have to look at most.

So if you're talking about dealing with your asthmatic athlete or your asthmatic patient, these are the muscles that you're going to look at a little bit more and maybe do a little bit more soft tissue work. Pectoralis minor, the serratus anterior, sternocleidomastoid, the scalenes-- both anticus and medius. And it works very well.

Now for clinical exercises, when we talk about this, clinically, what do you need to do for the asthmatic patient? What's the problem with the asthmatic patient in their pulmonary function? Generally, get too tight around here. So we have to loosen up these muscles with soft tissue. Will that be enough?

First of all, it's a good idea to teach them how to breathe properly, abdominal breathing. So the test you would use that often helps them is they lay on your table, you have them put one hand on the abdomen, one hand on the chest, and you have them take a couple of deep breaths in. And generally what they'll notice is the hand is going up and down.

And not the hand on the stomach, but it's the hand on the chest. This then becomes their exercise when they go home to help facilitate their breathing is they know they've got to make this hand go up and down. It's OK for this hand to rise a little bit. But now you can focus a little bit on their breathing patterns to help them relax at night.

The other exercise that we can do, geared specifically for some of these muscles and the problems they're having, have to do with stretching out in here in kind of a combination of using breathing patterns with light weights, and tension, and traction. And what we do-- you're all familiar with chest flies, right-- just light dumbbells coming down or overhead. What you do this is you do it with light weights with a breathing pattern. It's almost a combination of some of the yoga positions, but then using weights with tension.

And the way this would work is they would lay across a bench or across a Swiss ball. So if they have the ball behind their back, so they're laying down. They're holding the weights up. And I'm talking about light weights, 3 pounds, 5 pounds. Not much more than that to begin with.

They take a deep breath in. And then they breathe out but the weights don't come up. They let the weights stretch them out more. So the breath in to help expand and then breathe out, but the weights stay here. Then they take another breath in and let the weights come down a little bit more.

And then they breathe out and come up. So it's a two-breath count. And it allows them to expand.

If you try that, you'll probably notice it doesn't take much more than five, six, seven repetitions before you really feel the stretch. So they also have to be taught once again, don't overstretch. But it's an excellent way.

They can also do overhead. Light weight, holding it in here, breathe in and out, breathe in and out. What makes it very effective is it's a home exercise. They don't need a gym for this. They need light weights and that's it.

So these are the exercise they can focus on. Now if they're doing aerobic-type work, what they have to worry about is getting to that almost point of no return, where they start wheezing and they're having all kinds of trouble. They may have to do more interval work.

So if they find that at about 20 minutes, some of their asthmatic symptoms come on, they have to do interval work where they stop at 15. And then maybe do some easy stretching. Let the body balance out a little bit. And then go back and maybe do another 15 minutes. So interval work works well sometimes for the asthmatic patient.

Some of them find that swimming is good, the moisture, especially in a warm pool. But then in other cases, the chlorine from the pool affects them too greatly. So it would really be an individual-type thing, where are they training if they want to get some swim training in.

Because you can often have-- what happens when you have the asthmatic patient with the bad back or the asthmatic patient with arthritis? Sometimes you're actually trying to train and do exercise for two different conditions. And sometimes they're at odds with each other.

So that is basically the pulmonary function. We don't need to go into a lot of detail on that. Anyone have any questions on that? OK.

Let's get more into cardiovascular function. First term you should be familiar with is cardiac output. And it's signified by Q.

Cardiac output is heart rate times stroke volume. Stroke volume is the amount of blood that's pumped out of the left ventricle-- in one beat, how much blood is pumped out. And that is the stroke volume.

Now typically, if we look at sedentary versus trained people, heart rate times stroke volume. Now in the untrained person, it wouldn't be uncommon, a resting heart rate of approximately 70 and a normal stroke volume for an untrained person would also be 70. So their heart rate's 70 beats per minute.

The stroke volume is 70 milliliters, which is per beat. So if you multiply that, you can see that per minute, they are putting out approximately 4,900 milliliters, or 5 liters of blood per minute. That would be a standard.

Now with the trained person, generally, their heart rate is going to be lower. Now let's say they even dropped down to 50, OK? The training will increase their stroke volume dramatically. Their resting stroke volume might be 100.

So a lot less beats because the muscle-- the heart-- becomes so much more efficient, they're getting the same 5 liters of blood with 20 less beats per minute. So the heart is becoming much more efficient, much more effective. That's part of the training.

Now if we look at exercise. The exercise condition, we can see, generally, heart rate with exercise might go up about the same. If you look at max heart rate generally, that's going to be about the same. It's not going to change drastically.

So even if we go up, for example, to 150 for both patients, the stroke volume whereas the untrained person might go to 100, the untrained person may go 150 to 200. These are ballpark figures. But the ability for the trained person to increase their stroke volume is dramatically larger than the untrained person during exercise. So the ability to increase blood flow is also much larger.

Now the cardiac index is something that you may see at times. And this is the cardiac function divided by the body surface area. I have not used that a lot.

Then we can go to extraction of oxygen. Maximal oxygen consumption is the max cardiac output times the max a-vO2 difference. That is the amount of oxygen in the arterial blood minus the amount of oxygen in the venous blood. So that's how you would figure it out.

So you would take, for example, the 5 liters of blood and see what the difference in the a-vO2 extraction is. And that would give you the maximum amount of oxygen that is actually being brought to the tissue. a-vO2 at rest, you can see, 25%.

During exercise, you can grab 85% of the arterial oxygen and use it to the tissue. So at rest is 25%. Exercise is 85%.

Now also with the cardiac output when we talk electrical conduction. And with electrical conduction, we're not doing any kind of intervals. It's just something you should be aware of. This is when they do the EKG tests. I want you to be aware of with the EKG test because when we talk about health appraisal, we're going to start talking about something called PAR-Q.

And the problem is when you talk about patients as they get older, if they're in their 60s or 70s, you probably can't find a patient who doesn't have a problem with their electrical conduction. Something, some sort of problem. A depressed interval here. So when they start using-- it they start using stress testing and EKG testing to dictate or to determine whether they can exercise, these people are not going to be exercising. And we'll talk about the false positive when we talk about PAR-Qs and health testing for the older patient.

Now different cardiovascular phases of exercise. First of all, when we talk about cardiovascular, first is we're going to talk about anticipation. And this all relates to the heart rate. During this stage of exercise, the first thing that happens is anticipation, which will vary from event to event.

In a marathon runner, you're not going to see much change from the resting heart rate. In the 100 meters, when they're on that line, you may see almost maximum heart rates before they do anything at the beginning of the race. So that is the anticipatory reaction. So it will vary based on the different events.

The initiation is once the exercise starts, how quickly their heart rate goes up. So to touch on what we mentioned before, if they are a trained person, their heart rate will go up, level off, and go into a steady state. If they're untrained, it will be more gradual but it will go up to a higher level. They'll get to their maximum much quicker.

Then the adjustment is now when they start hitting that steady state. And remember, when I showed you before, oxygen consumption, you saw how there was a point where you had an oxygen deficit and then you start getting a steady state, the body started adjusting. This is the adjustments phase, where now the heart rate will plateau.

It'll start evening out. And then we end up with cardiovascular drift, which means even at steady state exercise, you'll start getting a gradual drift upwards. The heart rate will gradually start increasing upwards.

So what would be a good heart rate? We're going to talk about heart rate now. Standard heart rate in men-- this [INAUDIBLE]. Men, generally, 60 to 80. Women, 70 to 90.

Now using the heart rate, this is how we can help determine and help create an exercise benefit zone. Remember, we talked about that with exercise, the heart rate goes up in a linear fashion. So we can create a heart rate benefit zone where we can work at a percentage of our max VO2. And for cardiovascular benefit, generally, you want to be in that 70% to 90% of your max VO-- your max heart rate, I'm sorry.

How do we determine maximum heart rate? How do we determine maximum heart rate? 220 minus your age will give you the predicted maximum heart rate. So if we're trying to determine your exercise benefit zone, let's say in a 40-year-old patient, 220 minus 40, their maximum predicted heart rate would be 180.

So to get to the minimum levels of benefit for the cardiovascular system, you have to be at 70% of 180, which would be 126. 180 times 0.7 would be 126. Now the higher end of this, 180 times 0.9 would be 162. So that would become the exercise benefit zone right there, 126 to 162.

Now 90% for a lot of people is too much. What will happen at 90%? Lactate accumulation. So for a lot, they might have to be more in the 70% to 80%.

Now when you do this, if you have a patient on medications, you have to take into account the medications. So let's say you have a 60-year-old person, all right? You could say, with a 60-year-old person, the maximum predicted heart rate is 160. And that would give you a benefit zone of 60 times 7-- 70 and 6-- 102.

And then if we go up, let's go up to 80%. I'm not even going to go up to 90% on them, but 80%. 80 and 48. That would be their training zone. That's assuming they're not on any medications.

If they're on medications that are depressing their heart rate, this is not the equation that you can go by. You would have to do the equation based on what their maximum heart rate is with medication. So there, that type of person might need a stress test.

I've worked with cardiac patients before when I did cardiac rehab. And some of them, with their medications, they have a maximum heart rate of 108 or 114. So you'd have to base it more on that. So this is how we determine.

Now there is something you can do. Let's say you have an athlete who's in really good shape. You may have to change it because their resting heart rate is going to be much different. So what you can do is you're going to try and figure out-- it's something called Karvonen's Formula-- but that takes into account that their resting heart rate is much lower to begin with. And generally, they're going to have to get their heart rate up higher to get that benefit.

Now if you're swimming, this heart rate changes. If you're swimming, your maximum heart rate is going to be 205 minus age. Why would that be? Because swimming is in the horizontal position so the blood returns much more easily.

So you're not going to get your heart rate up. Because your efficiency is actually a little bit better, you're not going to have the same systolic ejection fraction. So your heart rate won't go up as high. All right.

So we have pregnancy. We have people who are trained well. Now the other thing is, which I gave you swimming. How about with stationary bike?

What kind of maximum heart rate are you going to have to get to on the stationary bike? You can't use the same heart rate. Why? You're using less muscle mass.

You're not using your upper body. You're using your lower body. So it's tougher to get the heart rate up. So if your maximum-- if before, if we look at this, if your range was 126 to 162, that would be very tough to get up to 162.

You're probably looking more at a range of 126 to 146, something like that. Be much tougher to get in. Serge, you have a question? OK. All right, so these are some of the differences in heart rate.

OK, so we're looking at these adaptations. We talked about heart rate. Let's talk about blood pressure.

Blood pressure, normal, 120 over 80, OK? The blood pressure generally, what you're worried about most is your diastolic value. Your systolic value may go up. Now the training in blood pressure is blood pressure will decrease at resting state. With exercise, blood pressure will decrease, the resting state.

So 100 over 60 would not be abnormal. When you do exercise, your systolic pressure should go up. You can go up to 160, 180. Your diastolic pressure should not go up that much.

Remember, the difference in systolic and diastolic pressure is the ability for the arteries to relax. If your diastolic pressure were to go up, you're not getting any relaxation. It would be hard to create a pulse pressure.

So it's OK for your blood pressure. Remember what we talked about at the very beginning of the day, the patient is in your office. Their blood pressure is 180 over 90, or 180 over 80, that's not a big problem.

Where you see some huge blood pressures, some of the weightlifters. And they have done some studies where they've put pressure cuffs around the legs during squat. And they have come up with some huge blood pressures, like 500 over 250 in blood pressure.

Now what's really striking about it-- now obviously, they're not doing it for more than one or two repetitions. We're not talking about someone doing this for 5 or 10 minutes, OK? One of the things that points to is the amount of reserve we have in the arteries, that we can handle that kind of pressure for short periods of time.

Now there is a theory out there-- I don't know if I want to call it a theory or an anecdote-- about the blood pressure almost having anti-aging effects. And the story that was always brought out to me is if you take two 65-year-old men, one has been a runner for 20 years, one has been a weightlifter for 20 years. The runner will look 65 or 70 years old, all right? The weight trainer may look 10 years, 15 years younger.

And you know, you just hear something like that and you go into the gym. And generally, a lot of endurance people, they're in great shape. But you know what? They do look their age.

Where you see some of these guys who have been training for years with weights. And they truly look younger. And the theory behind it is that the high blood pressure that's achieved with weight training profuses the entire body. Every tissue in the body gets flooded with blood at some point because the pressure is so high.

Whereas, if you look at someone who runs a nice, easy eight miles a day, where is most of that blood pressure going to? It's being shunted to the legs. You know, they're not getting it all over their body.

They're not getting that huge beet red-- excuse me, as I spit all over the screen-- the beet red face that you see with the weight trainers. So that's just one of the theories. It will be interesting to see how well that plays out when people look at it. All right.

Some of the other adaptations are anatomical. With endurance runners, you increase the volume of the left ventricle. Left ventricular volume is what increases with endurance and cardiovascular exercise. LVV, left ventricular volume.

If you're doing strength work and weight training, you are not getting that same adaptation. The adaptation you get is in the thickness of the interventricular wall because of the amount of pressure you're building up. So you increase the thickness of the interventricular wall with strength exercises.

Now the size of the heart, the volume of the heart will increase. So the question becomes, when do you see an increased heart in a person? It could be as an athlete or it could be someone with cardiomyopathy-- someone who has a diseased heart.

In men, generally, you can tell the difference. If you were to look at two hearts, you can tell the difference between a heart that's diseased, hearts of the same size. With some of the female athletes, it's a little tougher to tell. The sizes are a little closer as to whether it's a diseased heart or whether or not it's a healthy heart.

And we have the question, when you talk about cardiac function, one of the biggest things, when we talk about cardiac function, is sudden death. And what condition is most likely to cause this in athletes under 30? Cardiomyopathy, hypertrophic cardiomyopathy. Can you predict it? It's very hard.

If you're talking about a physical exam, it's almost impossible to tell. Even when they talk about doing testing, and screening, and EKGs, and the ultrasound, the echocardiogram, very tough to tell. In terms of expenses, it's just-- it's out of sight in terms of expenses. Not that we're measuring, you know, a death in terms of expenses. But if you can't afford to do the testing and provide care, it becomes a little bit too much.

When you look at some of the athletes who have died. One of the classic cases is Pete Maravich, who was a basketball player, who died when he was 41 or 42. He died during a basketball game. He had a heart attack. And when they looked at his heart, it was just totally diseased.

And they never were quite sure if he lived that long because he was such a great athlete or did that help facilitate his death. They weren't quite sure. Remember, as you sit here, it would really be hard to determine any artery closure or stenosis until you get about 70% closed. Most testing doesn't detect deficiencies until it's already 70% closed. All right.

And then you go and do an activity that you're not used to. And that's the problem. Who is more likely to suffer from a heart attack because they don't report symptoms, men or women? Women.

Women generally, will just, they'll just keep going. That's why it looks like women are more likely to die from heart attacks. So those are some of the adaptations.

Now if you're going to do a conservative management of hypertension-- and it's not something I do-- but one of the key points is this, is that the World Health Organization seems to think that hypertension is best managed by exercise, not by medications. And medications will also be determinant on what country you might be from. We generally are going to give medications much quicker in the United States than they might in the Scandinavian countries. So it's not a clear-cut case of, OK, this is your blood pressure. This is where you need medication.

So when we talk about high blood pressure, for example-- well, we'll get to that. But you can see the minimum physical examination-- and a lot of us aren't doing this in the office-- but the minimum would be, if you're dealing with hypertension, is the fundoscopic exam to see if they have any changes. A neck exam where you're looking for bruits, you can sometimes see in the carotid arteries.

The cardiac exam, which is just your typical cardiac exam. Abdominal exam for bruits, checking the abdominal aorta for any pulsing. Extremity exam for pulses, for any kind of swelling. One of the things I will pick up on patients often is the swelling in the ankles on the older patient, the ankle edema.

Because of technology and medication, we're getting more patients in our office. They're coming in for back pain. But more patients are living with congestive heart failure than before. So you are going to see more of this in your office.

And they may ask you, "Well, can I exercise?" And you have to tell them. You know, if they have cardiac problems, that's one of the kind of a red flag about whether you're going to tell them whether they should exercise or not. And then clinical laboratory screening, if you're doing that kind blood work.

Now on the evaluation-- let's go back here-- the evaluation of hypertension. First of all, if you're going to say that someone has hypertension, the blood pressure needs to be measured at least three times on two different occasions so that you have some sort of baseline. Because they could just come into your office, they may have just run in or something, or they're under a lot of stress.

You repeat the blood pressure on two occasions within the next four weeks. If the diastolic blood pressure is less than 90 millimeters, you monitor every three months for at least one year. If diastolic blood pressure is between 90 and 104, you continue to monitor blood pressure for three months, along with a lifestyle modification program.

Where that fits into our practices. It's not that we're managing hypertension. But there's a good chance we may be seeing the patient more than their family practitioners. We have some patients who are coming in on a regular basis-- some of the older patients with degenerative conditions and arthritic conditions. So we see them.

And if you already know that they may have some sort of problem, doing a blood pressure-- having your chiropractic assistant do a blood pressure as part of the exam-- it's a good idea to have that kind of value. So I'm suggesting maybe a little bit more of an interdisciplinary approach.

There's nothing wrong with you keeping track of blood pressure also. And letting their family physician, who might be managing their hypertension problem, giving them an idea. They may not see them as much on a regular basis.

After three months, if diastolic blood pressure's between 90 and 94, continue with current treatment regimen. If diastolic blood pressure is between 95 and 99, consider medical co-management for patients with cardiovascular risk or target organ disease. If diastolic blood pressure is 100 or greater, consider medical co-management. And that's if they're trying to take care of their blood pressure with an exercise program. OK.