Exercise Physiology- Part 4

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I want to introduce you to respiratory quotients. The respiratory quotient, now that you have is the ratio of carbon dioxide produced to oxygen consumed. So basically, the amount of carbon dioxide divided by the amount of oxygen, carbon dioxide produced over oxygen consumed. And you can see the different fuels have different RQ's, the reason for the importance of RQ is this is how sometimes they figure out what you're burning. Are you burning fats? Are you burning oxygen, based on the gases that you expel?

So if they're testing you, I don't know if you've ever gone through that type of testing, they actually will measure the gas that you expel. When we used to do it, we used to have these Douglas air bags we'd have to do, where you'd exercise with a clip on your nose, very uncomfortable, and you'd be breathing into a bag. These huge Douglas bags-- the physiologist from England had invented-- and then after you were done, you then have to collapse the bag, and you'd have to roll it up to make sure you got all the air out. And then you analyze how much carbon dioxide and how much oxygen is, and based on that, you get an idea of what type of fuel that you were using.

So if you look at this, you can see the RQ for carbohydrates is one, and that's because if we took a molecule of glucose and we add our oxygen, you're going to end up with six carbon dioxide, and six water molecules. So here's your carbon dioxide produced, six, over the oxygen you consumed is 6. So you can see the 1.0 ratio.

Now if we looked at a fat molecule, like palmitic acid, the thing we notice about fat molecules is how much less oxygen they have. So to metabolize it, you're going to have to take in a lot more oxygen. So in this case, to come up with a balanced equation, you'd actually be using 23 molecules of oxygen. And that would give you 16 carbon dioxide, and 16 water molecule. So, now, you're looking at 16 over 23. And there's your RQ as listed, 0.7.

Generally we have a mixed diet, we don't just burn carbohydrates, we don't just burn fat. So generally, we probably have a mixed diet that usually comes out when they work it out, the RQ usually comes out at about 0.82, which shows you that we generally tend to burn a little bit more fats. We often consider this our non-protein RQ. Our non-protein RQ because once again, the protein is negligible. Generally, the RQ isn't something you really need, unless you doing research, you're doing gas analysis. Just something to be familiar with.

Energy transfer and exercise then, immediate energy is your ATP phosphocreatine system, which really gives you, if you're going to use maximum, you have about five to eight seconds, that's it. If you're just using your ATP phosphocreatine, you have about eight seconds, and that is it. How long does it usually take to run the 100 meter? Not us, but people who can actually run it.

Yeah, it's about 9.0, 9.2, or something like that, anybody know what the world record is now?

It's 9.6.

It's 9.6, the world record?

Ben did 9.8.

Oh, yes, everybody remembers Ben Johnson. His was 9.8. So what that means is-- and they just broke it-- it's like 9.6. Yeah, all right, so, let's say it's 9.6, 9.7, what that tells us is someone is running with only enough energy for eight seconds, where are they getting the energy for that other 1.6? So the person who usually wins the 100 meter is not the person who's running the fastest at the end, it's the person who has slowed down the least. And, in fact, you can see, the peak acceleration occurs at about 70 meters, after that they're slowing down. So why does it seem like someone is really kicking and beating everybody? Because he's slowing down less than the other runners.

All right, that's it. They really for all intents and purposes barely breathe, I mean, they don't have to take any oxygen in. In fact, you'll see some of the short sprints in swimming, the head doesn't even come up anymore, OK, because they're not even breathing. So that's about the maximum you can do. Now, if you bring down the intensity a little bit, you can then go, if you go into your short term energy system, or the lactic acid system, you can exercise for about 60 to 180 seconds.

So that's good for-- that would be for an 800 meter runner, they're going to primarily use that system. For us, 60 to 180 seconds, that's going up there, getting a cup of coffee, will be about the same equivalent. Now, once again, it doesn't mean the ATP and phosphocreatine system is shut down, or that they're not using any aerobics, it's just that's the primary system.

Now during a short term energy, the lactic acid system, you start having lactate accumulation. And we talk about the blood lactate threshold. When we talk about the blood lactate threshold, and the accumulation of lactate, generally, we really don't start accumulating lactate until we get to at least 50% of our maximal exercise potential. So right now, as you're sitting here, you're probably all producing some, it's probably about two millimoles, right. That's probably your value.

After 50% of max, you start increasing. Now the difference between trained and untrained people, people who are untrained, they can start hitting 50% to 55%, and they will start accumulating, that is their lactate threshold. They'll start accumulating lactate at that point. So for some people, that might be walking fast. OK, for some people, it might be OK, I have to do a 10 minute mile, for others who might be an 8.

Now very trained athletes, what they'll do, is sometimes they can go to 80% to 90% of their max, in a trained athlete before they start accumulating lactate. I mean some of the marathon runners, the elite marathon runners, what do they average the first 25 miles? They're averaging about five minutes, or a 5:20, does anybody know what their average is? Is that does about accurate? And then after 25 miles, if they've done that, they kick it in the last mile and run a 4:40. All right, that's their kick, they run a 4:40 mile after they've done the first 25 miles.

Do you realize we couldn't even put together a relay to run a 4:40 mile? We'd probably have to-- we need 20 of us to each run 100 yards to put together a 4:40 mile. And that's what they're doing, why? Because most of the race they're aerobic, their maximum ability is so great, that what they can do is, even though they're at 80% of their max, 85%, they're not really producing that much lactate, they're able to clear it out that quickly. OK, so that is lactate threshold.

So what you'd almost see is something like this, if this was millimoles, let's go two, three, four, five. So the untrained person, if this is 50%, the untrained person is here, and about 50% you'll start seeing this increase in lactate. The trained person would be about the same in here, but then, you may not see it's almost 80%, it's in here they're still going flat, and then they'll start increasing. And they'll increase and they'll go up higher. So you might see that little bit of crossover in there. And that is the trained person. So that is the advantage.

Part of it is probably what we talked about previously, the glycogen sparing effect in terms of energy also, that's a benefit. But all that goes towards the training effect. And now, let's look at long term energy. the aerobic system, OK, so now, we're talking about a time greater than three minutes, greater than three minutes OK. And let's discuss oxygen consumption. Now the first term that I want you to see is Maximum V02. OK, you can see in your notes, the point at which oxygen consumption plateaus and shows no further increase with additional increases in workload, Or it could be very small increases.

Now here's what that would look like. Now if we look at V02 consumption, and we look at exercise time, what will happen is as you exercise at a certain intensity, you'll start increasing your oxygen consumption. And you're increasing, you're increasing, your oxygen consumption increases, and at a certain point in your exercise time intensity, the amount of oxygen you should be consuming to keep up with it is there, but you can't do it anymore, and your O2 either levels or plateaus off. The point at which you can't consume any more oxygen to keep up with the intensity, that is your maximum V02.

The maximum V02 is usually expressed in milliliters of oxygen per kilogram of body weight per minute. Now to give you some idea of values, what that would mean, OK, because a lot of people use maximum V02, as a symbol for aerobic fitness or conditioning. And if you have a good V02, you're in pretty good shape. We usually discuss aerobic capacity as a general guideline of how well someone is doing. A typical college student in good shape would probably be at about 50. A world class athlete, aerobic athlete, would probably be anywhere from 70 to 90.

The athletes who have tested out highest on this are usually the Nordic skiers, cross-country skiers. Now keep in mind, very important athletic concept, this 70 to 90, when we talk about athletes, it doesn't seem to matter just because you're at 90, doesn't mean you're going to be the athlete who wins. If you're the marathoner, if we take 20 marathoners, and we spread them out at two milliliter intervals from 70 to 90, the one who's at 90 won't necessarily win, the one who's at 70 might win. OK, so, it's not level of OK, you have this, the more you have, the better you're going to be. However, I can pretty much guarantee you that if you're at 50, you're not winning this race.

So there are minimal levels, and that's the one thing that we find in all of athletics. It is not the strongest, it is not the fastest who wins, or who is the best athlete, but you better have minimal levels. Right, you're not going to compete at an elite level unless you have certain minimal levels. So if we look at the NFL, if you look at the wide receivers, you ever hear the term, oh he's not that fast for a wide receiver, you know he's pretty slow? Yes, he's slow because, he doesn't run a 4.3 or a 4.4 but he's still running a 4.6. All right, he might be slow by wide receiver standards, but he is not a slow person, all right. And if he doesn't have that minimal level, he's not competing.

You're not going to find a wide receiver in the NFL who's running a 5.0. All right, it's just not happening. So he may not initially be the fastest, skills that definitely has a lot to do with it. If we looked at strength, you don't find the person who can squat the most, or can bench the most playing offensive line. There's too much skill involved, but I can also guarantee you, you're not finding an offensive lineman who weighs 220 pounds and benches 185. OK, so there are minimal levels that usually you have to reach.

This is one of the things I did when I did a study on rugby players, field rugby players, and we did a whole study on speed, endurance, muscle strength, muscle endurance. What we did is, we did all the testing, and we had nothing to do with selection of players. The players were selected, what we found is, when we matched up who was the fastest, we found that the fastest players weren't necessarily the ones picked, but we were able to come up with a minimal level, that if you didn't have this amount of strength, or this amount of endurance, you weren't picked for the team. So you can clearly see that there are minimal levels but not necessarily the maximum, that has to do with skill.

So we have maximum V02, now, let's talk about oxygen deficit. When we talk about oxygen deficit, here's our exercise. And here's our V02 consume that we need. Now if you're to do an activity, let's say, right now you're sitting, and you need this much oxygen for energy. Now you get up and you're going to run for 10 minutes. Now 10 minutes, that is a specific caloric expenditure, you need a certain amount of oxygen for that. So this might be the amount of oxygen you need for that 10 minutes, and then you sit again, and that's how much you need in there.

One of the things we know is that if you get up and run, at this point, it takes a while for the body to warm up. You're not going to be able to go right into your aerobic metabolism. So your aerobic consumption goes up on a curve in here, and eventually it reaches and it plateaus at the level it needs. This area right in here is your oxygen deficit. And that's why sometimes, you know when you first start, you're breathing a little bit more, and then you can kind of just level out, and you start getting comfortable.

Now when this exercise session is over now, and you sit down, are you still breathing hard? Yeah, you don't just automatically go back to your resting state, your pulse doesn't drop automatically down. What happens is, you keep breathing, your oxygen has got to make up for this deficit, and gradually, you start coming down. That is what we call oxygen debt. But you can see in your notes, what I gave you, is a lot of times that is now referred to as recovery oxygen.

And you can see EPOC, E-P-O-C. Excess post exercise oxygen consumption, that is your recovery oxygen. Excess post exercise oxygen consumption. Now, the better trained, you can liken this to the fact that almost, when you check into a hotel, you give them your credit card, that's the deficit. Well, at the end of the month, here comes the debt, all right, you've got to pay it off, at some point, you've got to pay. OK, now, when you pay it off, it depends on how well you're trained, if you're in very good condition, you actually end up here a lot quicker, you don't have as much oxygen deficit.

The exercise isn't too hard, you're in very good shape, and then you can find that these levels, these debt levels, come down very quickly. All right, now, when you recover from the exercise, often, depending on how hard the exercise was, you'll actually see, you'll have this first slope in here. That's what we call the fast component of oxygen recovery, that is the fast component. That's what gets you going right away.

You can see this slope in here, that takes longer, so you get a lot of oxygen in quickly, that's the fast component. And what do you think that's called? The slow component, thank you. That is your recovery oxygen. In a very intense exercise, this slow component could take up to 24 hours to level out, before you're before you've made up all of your oxygen deficit. The max V02, we discussed already, oxygen deficit, we've discussed. Any questions on the oxygen deficit at this point? And the recovery oxygen, and it's interesting because when we talk about work, keep this in mind about the concept of recovery oxygen, when we talk about will you burn more calories, and we get more exercise from walking versus running.

Exercise and recovery, first of all, let's talk about active versus passive. When we talk about active versus passive, they actually will serve two different functions. Active recovery will increase lactate metabolism. Active recovery increases lactate metabolism. Passive recovery increases glycogen synthesis.

So if you're done with an exercise, or if you're done with an event, what is the better thing to do? Is it better just to sit and rest? Or is it better to keep exercising sub-maximally? You have two different things going on, if you do active recovery, you're going to delay glycogen synthesis. If you do a passive recovery, you won't be doing anything to metabolize the lactate. So it may depend on what your plans are.

Let's say you're dealing with athletes who were at an event. Let's say you have a basketball tournament, and you have two games that day. All right, so you have a game at 12:00, they finish at 1:00. They have another game at 4:00, so you're trying to get some replenishment of energy, at the same time, you're trying to clear some of that lactate out. So you may have to combine, it may be a good idea where they do a sub-maximal activity afterwards, just to clear some of that lactate out.

And then you would have them rest for a replenishment. All right, so, if they end up at 1:00, and they have a 4:00 game, what kind of time constraint do you under? What time do you have to start getting ready for that 4:00 game? So that's an interesting thing. So that would be the active versus passive recovery. Now steady rate versus non steady rate exercise, that is just almost what I showed you with Max V02 before. Steady rate is where you're keeping a steady rate, it's generally easier for the metabolic to do that.

So if you are doing a lactate removal, you want to make sure it is a steady rate, sub-maximal, steady state, you don't want to be doing any type of interval work with that. Now recovery recommendations, then, for re-synthesis of high energy phosphates, ideally, would be some rest. Re-synthesis of high energy phosphates really, is just rest. If you rest for 5 or 10 minutes, you will start increasing your synthesis. Lactate removal, if that's your goal, it would be a sub-maximal activity.

You'll often see, I know a lot of professional athletes, who after a game, will get on a bike before they shower, and get out of that. They'll get on an exercise bike and just cycle very easily. You sometimes will actually see them on the sidelines, now, where they have a couple of exercise bike so they don't get tight. Replenishing body fluids, we'll get into that in more detail. But obviously, hydration, do you have to get electrolytes in? You do, but it depends on the activity. You may not be using-- if you're not talking about an activity that's greater than a half hour, or an hour, if you're talking about a short term activity, their electrolytes probably aren't being affected as much.

And replenishing glycogen, this has to do with some of the carbohydrate intake, that you try and get into their system. Now I'm much more involved with basketball and soccer, where typically, you'll have two soccer games in a day. You're talking about a 90, while at this level, you talk about an 80 to 90 minute activity, they may have two or three hours before. So what they have to do, is they have to come off the field, and almost get in a glucose supplementation, maybe one of the sports drinks right away. So there are ways that you can enhance recovery, both with exercise, and with supplementation.