Exercise Physiology- Part 2

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Let's talk about some of the energy from nutrient breakdown. Some of the energy from nutrient breakdown and carbohydrates. Let's talk about the specifics on carbohydrates.

First of all, it serves as an anaerobic energy source. It's the only macronutrient that serves as an anaerobic energy source. You're not going to get instant energy from fat or from protein. Carbohydrates is it. It serves as a metabolic primer. And we'll see that. I'll show you that a little bit later that in fact, you'll have trouble getting energy from fats and from proteins, unless you're burning some carbohydrate at the time.

We can see that acetyl-CoA becomes the key component there. And finally, it serves as brain food. Glucose in the blood is really what our brain responds to. That is our substrate. You cannot eat a Big Mac and fries and get energy and nutrients into the brain from that point of view. Now, during light and moderate exercise, about a third of our energy will come from carbohydrates.

Now, if we look at glycolysis-- glycolysis, a series of reactions in the first stage of glucose degradation-- it occurs in the cell, but it's outside the mitochondria. It's not in the mitochondria at that point. But it is in the cell.

Now, you have a rate limiting enzyme in glycolysis that appears to be phosphofructokinase. That appears to be the rate limiting step. Even though all the enzymes are important, every once in a while we pick out an enzyme that seems to be a rate limiting step. And if you have a weakness in this, that's where the problem will be.

Now, keep in mind there is aerobic glycolysis. And if you have aerobic glycolysis, you will not have a lactate buildup. Aerobic glycolysis will not give you a lactate buildup.

Now glycogenolysis, the breakdown of glycogen, limited by glycogen phosphorylase. Remember, what is one of the things that we said triggered this before? AMP. The AMP is one of the products from the ADP and the phosphocreatine. You end up with an ATP molecule and AMP. The AMP will now trigger the glycolysis to start working a little bit more. The glycolysis is on.

When we talk about energy systems, it's not on/off switches. It's light dimmer switches-- a little bit at a time.

Influenced by epinephrine. So we see hormonal influences are constantly affecting what happens with our metabolism. And we'll talk about some of the supplements later and how they affect it.

Now, the citric acid cycle-- some of you may know this as the Krebs cycle, the tricarboxylic acid cycle-- this is responsible for producing the intermediate compound acetyl-CoA. And you could see it's converted from pyruvate. I'll show you how this kind of enters the whole equation. This is the second stage of carbohydrate breakdown.

So if we're looking at the breakdown, we start glycolysis, and we're looking at the breakdown. And this is just the most basic form. Glycogen will be broken down. And you'll start with a glucose molecule. The glucose molecule will become pyruvate. Now, this is in the cell but outside the mitochondria.

The pyruvate will enter and become the acetyl-CoA. And that starts the citric acid cycle.

Now what we'll see down here is, alongside in here, this is where you're getting your electron transport along the way. Now, if for some reason you don't have the oxygen at this point, the pyruvate will end up accepting the extra hydrogen atoms. And pyruvate will become lactate. So we go into glycolysis, we break down glucose. This is aerobic glycolysis to this point, as long as we have enough oxygen. This will enter into the mitochondria, we'll get our acetyl-CoA. And I'll show you the citric acid cycle in a little bit.

The electron transport, the electrons are coming off. We're oxidizing the hydrogen. We're using electron transport system. This is how we're breaking the phosphate bonds and getting energy. So long as you have enough oxygen, the pyruvate will enter acetyl-CoA.

If you don't have enough oxygen, the pyruvate will start picking up these electrons and will become lactate. So you'll decrease the amount of product you have going into the mitochondria for energy. You'll increase lactate. And if you start increasing lactate, what will you be changing? The pH. And as you change the pH, now you're affecting the enzyme activity.

And if the enzyme activity is affected, then you don't have any of these chemical reactions occurring. You start becoming acidic in nature. You start dropping down to 7.1, 7.2. What is our normal pH? About 7.4 would be normal. It will start dropping down. It may decrease to 7.2.

Which in a lot of cases, when you're talking about pH of 7.2, if someone walked into an emergency with that, they would be worried with that kind of acidosis. Many athletes learn to train at 7.2. That's what makes them great athletes, their ability to train in acidic conditions, even though they're producing it.

OK. So that is pretty much in a nutshell, that would be the carbohydrates in there. We'll get to amounts and percentages later.

OK. From nutrient breakdown, the fats. OK. When we talk about fats, they are freeze dried energy. This is where we get most of our energy. You have enough reserve of fats in your body to run 750 miles, approximately. Right now in your body, you have enough energy. And it produces like 10,000-- some ridiculous number.

Obviously, we can't go out and run a 750-mile race right now. So there are limitations to that. But that's how much reserve energy have in there.

Serves as shock absorption. Most people don't realize it. And it serves as insulation. OK. One of the things most people-- you know, we attach judgments. Oh, you have this percent body fat. Fat is good. Fat is necessary. If we don't have a certain percentage of fat, you cannot have cell membranes without fat. When we talk about body composition, we're going to talk about certain basic assumptions. OK.

What would be the minimal percent body fat for a male? 2% is even pushing it. You're probably looking at 3% or 4%. 3%. I'll go with 3% is the absolute minimal. And for women? It would be about 12%. That's what we call essential body fat.

And there have been cases where they've done-- the case that I seem to remember the most, whenever you talk about body fat or any of these measurements, they usually encompass most of the people. But on the extremes, the equations don't work.

So I remember when Tony Dorsett was [INAUDIBLE] at the University of Pittsburgh, they did a body weighing on him. And he came out at minus 2%. He was negative body fat. All right. You know, was someone else carrying his cell membranes for him? Obviously what happened was, he was in great shape, he had very little body fat, so the equation really didn't match to him.

But with women, we have what we call essential body fat. You know, some marathoners, they are so light, they lose some of the fat from the kidney pads. Even regular runners. And that's why they have blood in their urine for a couple of days after, because their kidneys are taking a pounding over 26-mile race. So someone who trains a lot of miles, you wouldn't be surprised to find maybe some blood cells in the urine based on that.

Women really should not be going below 12%. Now, do a lot of women go below 12%? A lot of competitive athletes, absolutely. They go to 9%, 10%, which upsets their hormonal balance. And that's why a lot of them become amenorrheic or dysmenorrheic. The good news seems to be that most of these women, when they finish the competition, they generally go back to a normal hormonal balance.

But I remember, I think about a year ago, two years ago, I was reading a story. One of the fertility clinics in Minneapolis a lot of women were going, they found that one of the most effective treatments were getting some of the women to stop exercising. Because a lot of women, career women, very dedicated to their exercise program, staying in shape, well, they were keeping in such good shape, their hormone balance really couldn't support a baby or getting pregnant. And then when they dropped down a little bit, their hormonal balance evened out. And they had no problems with fertility.

So that was an interesting story in there.

The metabolism. Adipocytes consist of 95% triglycerides. These are the fat cells that are stored in our body. Glycolysis provides 30% to 80% of the body energy. And the whole concept is you liberate free fatty acids, which then travel through the bloodstream. They attach to the plasma albumin as they travel through. Very rarely you're going to find free fatty acids just floating around.

The training effect-- now, there is a training effect. The better condition that you're in, the quicker you can liberate and mobilize the free fatty acids. The quicker you can do that, the less glycogen you will use. That is the glycogen sparing effect. It's the difference between a trained runner and an untrained runner. Elite marathoners do not hit the wall at 18 miles. Untrained runners generally do have a problem with that.

Beta oxidation. This is the reaction of converting fatty acids to acetyl-CoA in the mitochondria. Let's take a look now at how some of this fits together.

OK. Now here's our glucose and glycogen breakdown that I talked about-- glycolysis to pyruvate to acetyl-CoA enters the citric acid cycle. Now, the fat, you have the beta oxidation here, but it feeds into the acetyl-CoA. So what would happen if you ran out of carbohydrates? The beta oxidation produces-- you have no acetyl-CoA for these electrons to get into. The fat substrate can't be used.

This is what we often talk about, the carbohydrates being the primer. Protein, which isn't often used as an energy source, same thing. Some of it goes into pyruvate. But for the most part, it also enters and attaches into the acetyl-CoA. It creates acetyl-CoA.

So if you don't have the acetyl-CoA there from the carbohydrates, you're stuck. Often what happens is, they have trouble, they have the carbohydrates, they have to go into reserve. And until they can get into the reserve of carbohydrates, they have no carbohydrates to burn the fats. And that's that portion where they feel like they hit the wall and they have no energy. And then they kind of get the reserves, the glucose and glycogen, from the liver. And that kicks in, then they can use their fats again.

So this is what we mean about burning in a carbohydrate flame. The quicker that you can get into using your fats so that you're not burning so much carbohydrate, you spare the carbohydrate. And that's how much more reserve energy you have.

The trained athletes, I mean, they start a race. And 10 to 15 minutes into it, they're using predominantly their fats. OK. So that's the key point in there.

Carnitine. Here's a supplement that people have been talking about. I Thought I'd mention it. What I've been doing is just picking out supplements here and there. The carnitine, this facilitates the breakdown of the free fatty acids. It actually helps get them into the mitochondria. And it's the L-carnitine. There's another form, I think it's DL-carnitine, which actually would be toxic. All right. It is a supplement that's been advertised. The research does not support it right now.

Interestingly enough, they found another use for it. It seems that the carnitine is a vasodilator in the peripheral tissue. And they've actually done research. So where they originally started carnitine to see how it helps with energy production, it shifted over a little bit. There was a study that showed it as a peripheral dilator. It increased oxygen to the tissue. It seemed to decrease delayed onset muscle soreness-- that people were using carnitine had less post-exercise muscle soreness, as opposed to people who were using a placebo.

Which often happens, where you use something for one thing, find out it doesn't work, and then you find the side effect. I think that's-- which was the drug for the hair that originally was used for cardiac patients, and they found the cardiac patients were growing hair on top of their head, and they switched over their use?

Rogaine?

Rogaine. Wasn't it Rogaine? I think, it was originally a drug used for cardiac function. They wanted to see if it helped heart patients. And the heart patients, who generally are older, male pattern baldness, they started growing hair. So they said, well, it's not working for the heart, but it's a hell of a hair drug. All right. So you'll see that happen every once in a while.

How about lipid intake? OK. When we talk about lipid intake? There are so many diets out there, sometimes it's hard to keep track. Generally, what I can seem to [? cull ?] from most people is, that no matter what, you must keep it under 30%. If you can keep your fat, that percentage of your diet, under 30%, you're doing OK.

Now, some diets want you to keep a much lower fat intake. Right. One of the things about that is it tastes good. So it's in some cases, it's almost a bit of an appetite suppressor. That if you [? didn't ?] have any fat in your diet, your appetite would probably actually increase a little bit. Plus, the fact that you need a certain amount of fat in there anyway.

Polyunsaturated to saturated fat ratios. Obviously this is a big topic. 2 to 1, at least, in terms of polyunsaturated to saturated fats. The trans fats, obviously, are something you avoid. OK. If you're cooking in oil, the olive oil without doubt seems to be the best.

Once again, something I picked up from Dr. [? Penn's ?] lecture, and I think most of the research is indicating, the Mediterranean diet seems to be the best diet. And it's not a diet per se. It's just how people eat. When you're talk about a lot of fruits, a lot of vegetables, nuts, keeping the red meat down, it just makes sense. So that's what they call the Mediterranean diet.

So let's talk a couple of questions. First of all, here's a question that you're going to get asked by a number of your patients when they talk about exercise. There was a claim that was being made that if you exercise at a lower intensity, you can burn more fat. Have you heard that claim? What do you tell them when they tell you that?

[INAUDIBLE] higher percent fat.

Yeah. You're burning a higher percentage of fat. Because from that standpoint, technically, you guys are doing a tremendous job of burning fat right now. At the intensity that you're working right now, really, when you think of it, you're basically probably burning 95% fat right now. Maybe 96%, 97% fat.

But the question is, when you're talking about exercise, let's say you're going to exercise. When we talk about exercise, you can work at 75% of your max, or you can work at 50% of your max. OK. And we'll do this for an hour. You will burn a greater percentage of fat at the lower intensity, a greater percentage.

The question is, how many calories are you burning total? If you're burning a significant-- if you run 75% max, you're probably burning three to four times the amount of calories than if you work at 50%. Even twice. So just percentage-wise, would you rather burn a higher percentage?

Let's talk about someone who exercises per time for one hour. That would make a lot more sense. So in one hour, someone who might be working at 75% of the max will burn approximately-- let's see. At one hour, 75% of max, let's say they're doing 9-minute miles. So maybe they're getting in about 7 miles. So at 7 miles, they might be burning, if they're 200 pounds, they might be burning about 1,400 calories, approximately.

You take that same person 50% of max. Maybe they're doing a 12-minute. So they're probably only going about 4 miles. At 4 miles, they're probably burning about 800. So you can see that's a 600 difference. So even though you're burning a greater percentage of fat, you're burning a greater amount of total calories at the higher intensity.

Now, if you go too high, what happens? You produce lactate, you just can't exercise as long. So that's why, given a choice, I still recommend that you work at the higher intensity.

Now, there are certain caveats we put on that depending on the age of the patient. We'll get into that when they're exercising. But generally, people are working at a lower total calorie. So even though they're burning a higher percentage, they're still burning a lot less calories. And it still comes down to calorie burn.

If you burn more calories, even if it's carbohydrates, you will end up burning the fat reserves.