

## Heart Rate

Why do we measure heart rate during exercise? The answer to this question seems rather obvious ... but sometimes the obvious answer leads us to overlook some important physiological responses during exercise and the usefulness of heart rate can be lost.

Heart rate is simply a measure of how fast the heart is beating and typically represented in units of beats per minute (bpm). This is an easy measure to take with the availability of heart rate monitors ... Polar, Garmin, Timex, Suunto, etc. ... there are many manufacturers of heart rate monitors and they all perform rather similarly in that you get a consistent and valid measure.

But why is it important to know how fast the heart is beating? Many people will give an answer like "It tells us how hard the heart is working." Technically, this is not correct ... to know how hard the heart is working we would need to know the blood pressure response as well as the heart rate.

We measure heart rate during exercise because it gives us a sense of how much oxygen we are consuming. (There is a lot of physiology that I need to present to justify that statement ... so hold on ... here we go!) From a very basic perspective, muscles generate force to cause movement. To create force, muscles transform chemical energy to mechanical energy. Much like the engine of your car which transforms energy in fuel to (ultimately) create a force that makes the wheels move.

Muscles generate force by transforming energy anaerobically (without oxygen) and aerobically (with oxygen) to create force. You cannot exercise that long without oxygen ... remember those swimming drills where you take a breath every 3 or 5 strokes? That can be hard to do for long! So let me focus on the aerobic process of generating force.

Muscles need oxygen to generate force during endurance exercise. As intensity of exercise increases, we need to consume more and more oxygen. The oxygen is used to transform chemical energy (e.g., carbohydrates, fats) to mechanical energy (e.g., movement). You take deeper and more breaths as you start exercising harder and harder in order to get more oxygen to the muscles. Oxygen needs to get from the lungs to the working muscles ... that happens because of the circulatory system. Blood is pumped through the lungs to pick up oxygen, then the 'oxygenated' blood is pumped out to the working muscles. The muscles pull the oxygen out of the blood ... and the 'deoxygenated' blood is pumped back to the lungs to pick up more oxygen.

If I really want to know how hard exercise is, I would want to know how much and how fast oxygen is being used by the muscles. That is the most important factor when quantifying exercise intensity because that tells how chemical energy (carbohydrates and fats) is being transformed to mechanical energy. Knowing how much oxygen is used tells us how many calories are used. In order to measure how much oxygen is being used, you would need to breath into a special mask so all the air that you inspire and expire is measured ... that's not easy and the instruments to measure oxygen is expensive. This is where heart rate starts to come back into the picture.

We can figure out how much and how fast oxygen is being used if we know three things (for those of you that want to read more on this, just google 'Fick Equation'):

1. How fast the heart is beating (i.e., Heart Rate).
2. How much blood is pumped with each beat (we call this 'Stroke Volume').
3. How much oxygen is pulled out of the blood by the working muscles.

What is really interesting is that each of these parameters change in a predictable manner as exercise intensity increases. That means that we could measure any one of the parameters and then predict how much and how fast oxygen is being used. That's cool ... because of the three parameters, the easiest one to measure during exercise is Heart Rate!

So ... why do we measure Heart Rate during exercise? To get a sense of how much and how fast we are using oxygen! That's it ... nothing more to it.

Now, many people know that heart rate can be different on different days even if we are running the same speed. That can happen because heart rate is only 1 of 3 parameters that determines oxygen use! Heart rate (by itself) does not always tell us how much oxygen is used because either stroke volume and/or the amount of oxygen pulled out of blood by the muscles can change. Here's an example: When you watch a scary movie, typically, your heart rate increases ... but that does not mean you are using more oxygen. When you get scared, the stroke volume can decrease while heart rate increases ... which means there may be no change in oxygen consumption!

The same thing can happen during exercise. Sometimes, the amount of blood pumped with each beat can vary between days (when you are running the same speed) or even between types of exercise. For example, your heart rate is probably a bit lower when cycling vs. running. Part of that has to do with the position of the body that can influence stroke volume (how much blood pumped with each beat). Because stroke volume changes, heart rate also changes ... so when we predict the oxygen used during cycling using heart rate only, we have to use a different equation than running because stroke volume changes. The same thing happens when we swim ... putting the body in a horizontal position and having water pressure pushing on the body influences stroke volume ... and that means heart rate will be different for a given oxygen consumption.

This does not mean that heart rate is not a good indicator of intensity ... instead, it is important to understand that we are really trying to get a sense of how much oxygen is being used and heart rate is a good predictor of that (but it is only 1 of 3 factors that influences oxygen used).

So what can you do with this information? Heart rate is a really easy measure to define exercise intensity ... because of that, your coach may tell you to exercise in different 'training zones' based on heart rate or, you may communicate to your coach what your heart rate was during a workout. In both of these examples, heart rate is being used to describe the intensity of exercise ... and this works well when there is a good understanding of the limitation of heart rate in predicting oxygen used. But remember, heart rate is one of three factors that is used to understand oxygen cost of exercise ... and that is the critical parameter that defines exercise intensity.