Heart Rate and Cardiovascular Efficiency
By Tiffiny Twardowsky, MS

When starting, changing or maintaining an exercise program it is important to understand how your body responds to various workloads and conditions. Monitoring heart rate during exercise can show physiological improvements, determine whether the intensity should be increased or decreased, and warn you of stress caused by environmental factors. Understanding maximum heart rate, target heart rate, and how the heart responds during rest and exercise can assist in designing an effective exercise program.

Maximum Heart Rate
The maximum heart rate of an individual is the highest heart rate one can achieve. Accurately measuring maximum heart rate can be done taking a treadmill test while measuring the volume of oxygen (VO2) consumed and the volume of carbon dioxide (CO2) exhaled. The level of exercise intensity is directly proportional to heart rate and the amount of oxygen (fuel) required by the body. In other words, as exercise intensity increases, a greater amount of oxygen is required by the working muscles. The heart rate, which is the limiting factor of the three, increases so that oxygen can be delivered to the body. When the heart rate reaches maximum, the volume of O2 that can be consumed by the body reaches its maximum. This is called VO2 Max. At this point the volume of oxygen consumed is equal to the volume of CO2 exhaled; there can be no further increase in exercise intensity, heart rate, or VO2 max.

In general, oxygen requirement for any given workload is the same whether an individual is an elite athlete or an overweight couch potato. The oxygen delivery system, the cardiovascular system, is one of two main factors that limit the body to reaching a certain level of intensity (the other is how much oxygen is extracted by the muscles from the blood). The efficiency of the cardiovascular system is extremely different in the elite athlete versus the overweight couch potato. The sedentary individual will have a much lower VO2 max and therefore a lower maximum exercise intensity. This is why the sedentary individual huffs and puffs going up the stairs while a regular exerciser will climb with greater ease. The sedentary person’s cardiovascular system is not as efficient in delivering oxygen to the working muscles and therefore needs to work harder and faster.

Cardiovascular efficiency depends on a number of factors. One measure is called stroke volume, which is the volume of blood pumped per heartbeat. A fit individual has a larger stroke volume, which means a greater volume of oxygen is delivered to the body per heartbeat. This is also the reason fit people have a lower resting heart rate. As mentioned, muscles require a given amount of fuel, even at rest, which doesn't change with exercise training. Because exercise training has increased the volume of oxygen that can be delivered to the muscles per heartbeat, the heart needs to beat less to do the same job. Therefore the heart rate is lowered.

Maximum heart rate can also be estimated using a simple equation. MHR=220-age. As you can see, MHR decreases with age. This means that VO2 max and maximum exercise intensity also decrease with age. This decrease is due to a number of cardiovascular changes. A decrease in the number of heart muscle cells that control heart rate as well as the degeneration of these cells reduces the strength of the heart. Deposits of fat and other material into the heart causes heart muscle cells to degenerate and become stiffer. These changes reduce the strength of the heart and therefore the amount of blood the heart can pump. The walls of the heart also thicken with age, which decreases the amount of blood the heart chambers can hold. Another result of aging
is a decrease in the number of blood vessels that lead to the heart, thereby reducing the amount of oxygen that can reach the heart muscle. There is also a decrease in muscle mass, which causes less oxygen to be extracted by the working muscles.

**Target Heart Rate**
The same changes that affect maximum heart rate will also affect and person's target heart rate (THR) for exercise. THR represents the minimum and maximum number of heartbeats per minute (level of exertion) during exercise to achieve efficient cardiovascular benefits. The American College of Sportsmedicine recommends an intensity level of 60% to 85% of maximum heart rate. Here is a simple formula for determining your target zone.

1) Calculate MHR
   
   \[ MHR = 220 \text{ - age} \]

   **Example for a 33 year old**
   
   \[ 220 - 33 = 187 \text{ (MHR)} \]

2) Calculate minimum THR
   
   **Lower limit = MHR \times 0.60**

   **Example**
   
   \[ 187 \times 0.60 = 112 \text{ (lower limit)} \]

3) Calculate maximum THR
   
   **Upper limit = MHR \times 0.85**

   **Example**
   
   \[ 187 \times 0.85 = 159 \text{ (upper limit)} \]

The greatest advantage in taking an exercise heart rate is the ability to account for improvement. For example, let's say a 35 year old female begins an exercise program of walking for 30 minutes at 3 miles per hour. In the beginning she may get an exercise heart rate of about 145 beats per minute (BPM). Over time, as the cardiovascular and muscular skeletal system becomes more efficient, she might get an exercise heart rate of 130 BPM. This is revealing that her heart doesn't have to work as hard at the same intensity level. This can also be explained by keeping the heart rate the same and increasing the workload over time. If this person wanted to maintain a heart rate of 145, she would have to consistently increase the intensity as the body becomes more efficient in delivering oxygen.

**The Fat Burning Myth**
Target heart rate should be used as a general guideline - an indicator of how hard you are working. When working at the upper range a greater number of calories are burned per minute when compared to working at the lower range. However, when working at the lower range a greater number of fat calories are burned. So, which is better?

When exercising at a lower intensity for 30 minutes, you might burn about 200 calories with about 80% coming from fat. This means that 160 calories of fat are burned. When exercising at a higher intensity for 30 minutes, you might burn about 300 calories with about 60% coming from fat. This means that 180 calories of fat are burned. So, even though the lower intensity burns a greater percentage of calories from fat, the higher intensity burns a greater amount of fat calories.

When it comes to weight loss however, the bottom line is not how many fat calories are expended, but how many total calories are expended. The advantage of exercising at a higher intensity for weight loss is that it will take a shorter period of time to burn calories.

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