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THE LIMITATIONS OF TRAINING WITH HEART RATE AND THE CRUCIAL INFORMATION MUSCLE OXYGENATION CAN OFFER YOU

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Athletes today have access to more information than ever before. Whether it be motion trackers analyzing your every step, or wearables measuring how your body is functioning, there are many forms of data available at your fingertips. But the question is: what metrics are the most valuable for helping athletes improve at their sport?

The old

Focusing specifically on the wearables that tell you what's going on inside of your body, heart rate (HR) monitors are the most common and have been around the longest. Heart rate monitors can come in the form of chest straps or wrist worn straps. The beats per minute measurement reported from HR monitors tells you how your body is responding to an activity, which is a useful metric in certain scenarios. As you increase the intensity during a run, your HR will increase, and correspondingly as you slow down, your HR will also decrease. The value in HR training is in the use of zones, which are all based off of your HR relative to your maximum HR. However, multiple **issues with HR monitoring** for athletes exist, such as:

1. Maximum HR is often calculated using the formula 220 minus the age of the person, or similar formulas. No consideration is given for physical fitness, body composition, or other individual variances which could affect this maximum value.
2. HR is dependent on multiple external factors, such as caffeine intake, the temperature outside, or even sleep. Therefore, HR may be unreliable unless measured under extremely controlled environments.
3. HR is a systemic measurement. It tells you how your heart is adjusting to activity, with nothing specific about how the working part of your body is responding to exertion.

That's why there is a need for another type of measurement that can provide individualized feedback for athletes.

The new

Muscle oxygenation is measurement that has come into play as a useful parameter to help athletes optimize their performance. Muscle oxygenation (SmO2) refers

to the amount of oxygen in the blood of your muscles. The technology behind muscle oxygenation monitors was developed several decades ago and devices on the market today work by non-invasively measuring the amount of oxygenated and deoxygenated blood in the muscles using light waves. The ratio of blood that has oxygen compared to the total amount of blood is what SmO2 represents (as a percentage). As your muscles are working harder, more oxygen is used and the SmO2 decreases. Therefore, SmO2 provides athletes with a localized measurement for how muscles are performing during an activity. Some of **the benefits from using SmO2** can be found in circumstances such as:

1. Measuring localized muscle performance. The way in which the oxygen is supplied and consumed in the muscle can be monitored without the use of any assumptions.
2. Working muscles are being exerted beyond their limits. SmO2 can inform the athlete that their muscles are running low on oxygen and they cannot sustain the current activity.
3. Evaluating muscle recovery. SmO2 can show the rate at which the oxygen is delivered back in the muscles and when the muscles are ready to perform again.

SmO2 is the future of optimizing athletic training on an individualized level by monitoring the working muscles.

See it for yourself

Check out the two graphs below. The athletes were performing an incremental step test on a stationary bike while wearing a chest strap HR monitor and a muscle oxygenation sensor on their quad muscle. The bike power was increased by 30 W every four minutes (power is shown at the top in between the vertical black dotted lines) and the subjects stopped when they reached voluntary exhaustion. A cool down was then recorded at 30 W at the end of the test.

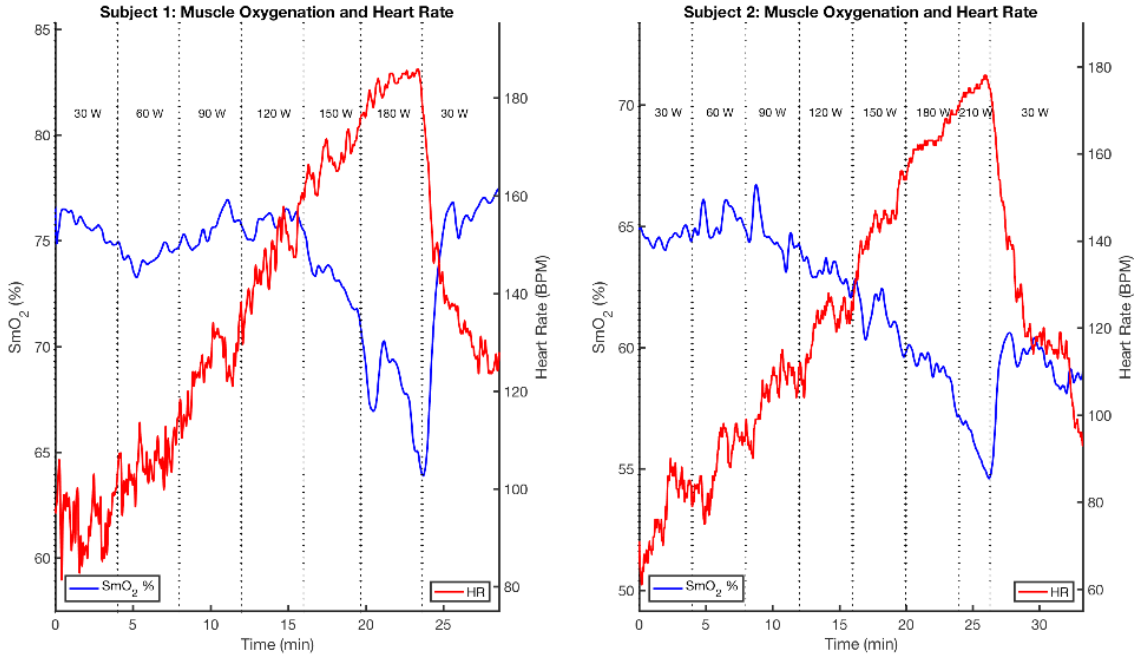
1. Threshold

Looking at the HR (red line) on both plots, you can see how it increases linearly as the workout gets progressively more difficult. However, there is no clear indication when the athlete may be hitting his or her limit especially considering how heart rate can be impacted by the external factors mentioned above, such as caffeine

intake, sleep, and temperature. These factors may cause the HR line to shift up or down, making it very difficult to determine the limit. By taking a look at the SmO2 % (blue line) however, you can see how subject 1 and subject 2 show a dramatic drop around the 180 W and 210 W power, respectively. This drop in SmO2 indicates that the muscles are using much more oxygen than what can be supplied by the blood. Therefore, the muscles are being worked at an unsustainable pace and the athlete won't be able to continue the activity for long.

2. Recovery

Once the athletes reach exhaustion, they begin to recover back at 30 W. During the recovery period, the heart rate decreases rapidly and the trends appear very similar for both athletes. As for the SmO2, both athletes experience an initial increase indicating that the oxygen is returning to the muscles, however, the two athletes have very different recovery responses. Note how for subject 1, the increasing SmO2 trend shows the oxygen is returning to the muscles at a rapid pace and magnitude returns to the baseline value after a couple minutes. Compare that to the recovery for subject 2, who's SmO2 does not return to baseline after several minutes. This indicates that this athlete is extremely fatigued and his muscles will not be ready for another activity following this test.



Overall, the SmO2 recovery response provides much more information compared to just looking at the heart rate. Muscle oxygenation can guide athletes' training by examining how their muscles are responding to exertion and recovery.