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INTERVAL TRAINING WITH MUSCLE OXYGENATION

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For most athletes, training consists of a mixture of speed work and endurance work. Speed work is typically performed by doing interval sets, which prescribe successive periods of high intensity effort followed by a recovery phase. These speed workouts may include runners sprinting around a track or cyclists working at a high power for short stretches of time. Athletes can face several challenges during speed training such as:

- Understanding how hard they have pushed their muscles during each set
- Knowing when their muscles are recovered and ready to begin the next set
- Recognizing when to stop the intervals due to overall muscle fatigue

If you've ever faced any of these challenges, this article explains how monitoring muscle oxygenation can help.

What muscle oxygen monitors measure

Muscle oxygen monitors use optical techniques to measure the oxygenated hemoglobin concentration (HbO_2) and deoxygenated hemoglobin concentration (Hb) in the muscle as an athlete exercises. These devices are able to do this by shining near-infrared light into the muscle and detecting the light reflected back. By measuring the amount of light that is absorbed, the sensor can determine the hemoglobin concentrations. The parameter that is typically reported to the athlete is called muscle oxygenation (SmO_2), which is the ratio of HbO_2 to total hemoglobin concentration ($HbT = HbO_2 + Hb$).

Understanding the data

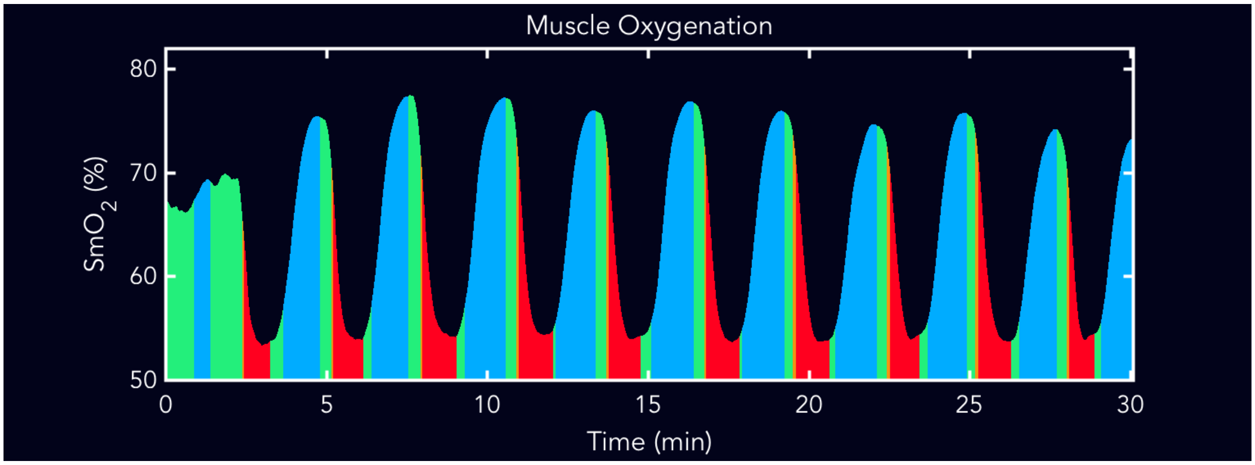
There are two primary factors that influence the SmO_2 measurement throughout exercise: oxygen delivery and oxygen consumption.

- Sprinting: As the muscles are undergoing higher exertion work, they demand more oxygen and therefore the blood supply to the muscle is increased.[1,2] This increase is accomplished primarily by an increase in heart rate. There is a point, however, when this blood supply increase can no longer match the oxygen demand within the muscle, which can be seen by a decrease in SmO_2.
- Recovering: When the athlete slows down during the recovery phase of an interval set, the SmO_2 increases due to the lower oxygen requirement in the muscles in addition to the high blood supply still being present.

An example of speed training can be seen in the figure below, where an athlete is wearing the Humon Hex muscle oxygen monitor on his quad during a cycling workout. The SmO_2 begins around 68% and gradually increases during the initial two minute warm up phase at 50 W as the capillaries dilate within the muscle and more oxygen is supplied to the tissue. By monitoring this oxygen increase in real-time, the athlete can ensure he or she is ready to begin the activity once sufficiently warmup up.

Once warmed up the athlete starts the interval sets. During the high-power portion of the speed training, in this example at 250 W, a rapid decrease in SmO2 is observed. A sufficiently large decrease is colored red in the graph, indicating when the oxygen depletion is occurring at a rapid rate. As the decrease in SmO_2 begins to plateau, here around 53%, the Humon Hex alerts the athlete prompting him to enter the recovery phase by reducing cycling power to 50 W. By entering recovery when prompted, the athlete can make sure to push sufficiently hard to improve their abilities, but still be able to endure their entire workout before extreme fatigue sets in. For athletes looking to perform more anaerobic training, they may choose to remain training in a lower SmO_2 state.

The recovery portion is identified by the blue in the graph and this fast increase in SmO_2 is due to the low muscle oxygen consumption at the low power output, but still having high blood supply due to the previous sprint phase. The Humon Hex monitors this recovery and prompts the athlete when it is time to begin the next interval.



How to use the data

The patterns in SmO_2 during speed workouts provide athletes with information about what is going on inside their muscles. The SmO_2 trends during the high exertion and recovery phases can help guide athletes speed workouts to be efficient and effective.

Optimizing Recovery

After stopping a high intensity portion of an interval, SmO_2 data will show when the muscles are in a recovery phase (marked as blue by the Humon app) and when the muscles are ready to perform again (marked as green by the Humon app). The length of time it takes the muscles to recover is indicative of the exertion level during that set.[3] Muscles will take more time to recover if they are pushed harder or are becoming more fatigued. The Humon Hex can tell an athlete how long their muscles took to recover and monitor this for all of their speed training.

Another aspect of recovery that is important to monitor is how high the SmO_2 gets during each recovery phase during speed training. Looking at the graph above, it can be seen that the peak SmO2 level after the high intensity red portions all reach around 74-75%, except for the last two recovery phases. This tapering off of the maximum SmO_2 during the last couple recovery portions indicate overall muscle fatigue, which usually means the speed workout should come to an end. If athletes overexert themselves and push too far, they risk deconditioning their muscles which can inhibit overall performance.

Pushing the limit

By examining how far the SmO_2 dropped during each interval set, muscle oxygenation monitoring allows athletes to track exertion throughout a workout. Optical monitoring techniques have been used to assess muscle performance for sprint training.[4,5] In the example shown on page two, the athlete was pushing at the same wattage (250) during each set and the SmO_2 consistently decreases to around 53%. If there were inconsistencies during the training or the athlete couldn't reach the desired intensity during the sprints at the end of the workout, the SmO_2 drop would reflect how the muscles were consuming the oxygen available. This information can allow athletes to understand more about what is going on inside their muscles and improve the way they train.

References

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