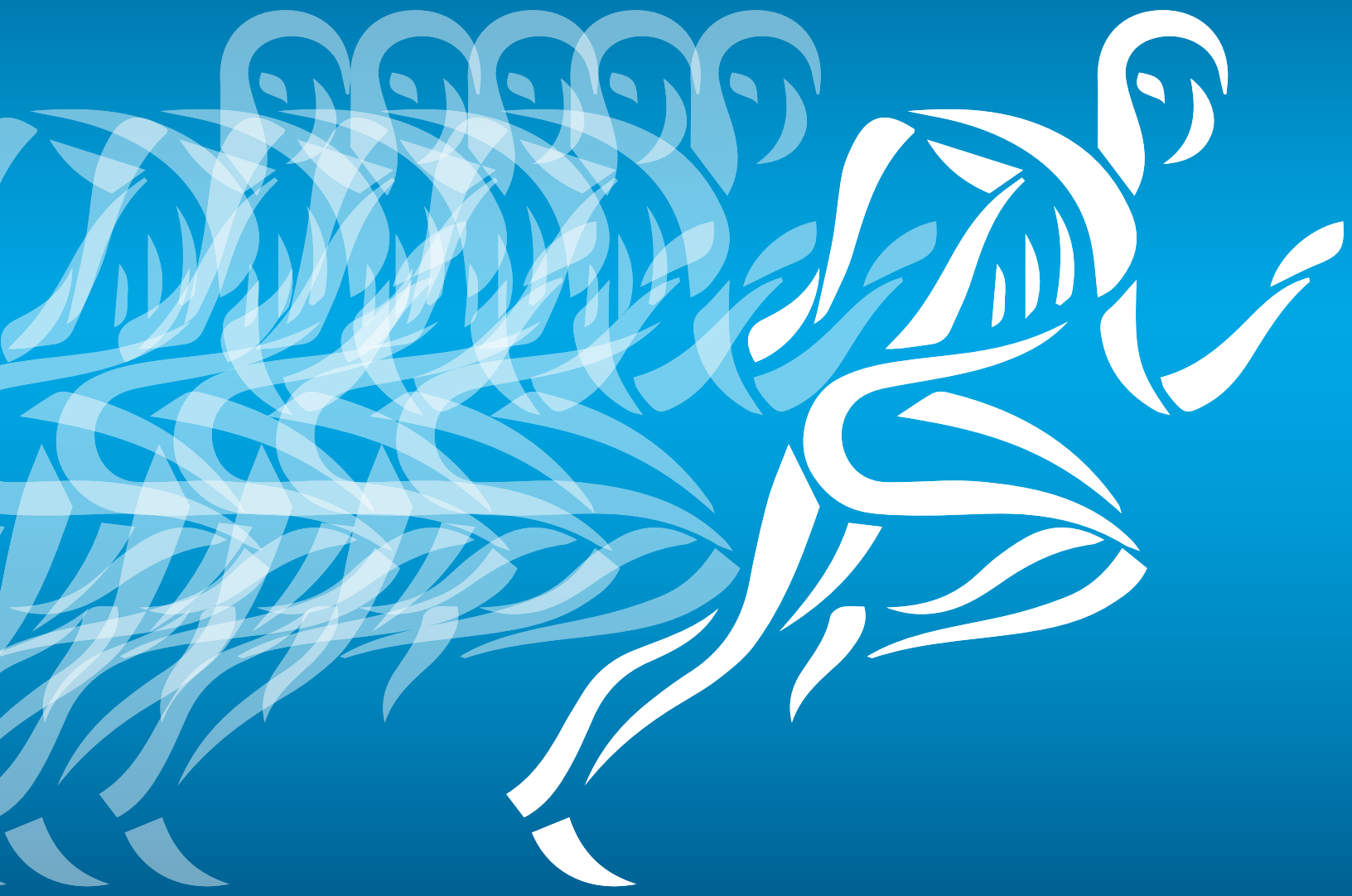
MUSCLE OXYGEN



Using Muscle Oxygen to Guide Interval Training

USING MUSCLE OXYGEN TO GUIDE INTERVAL TRAINING

Our **first eBook** endeavored to establish Muscle Oxygen as a precise and universally applicable way to measure training intensity levels in athletes. In it, we argued that Muscle Oxygen provides accurate and continuous measurement and monitoring of the intensity level and duration of specific muscles, giving athletes and coaches the ability to adjust training in real time to better induce physiological adaptations.

In this second eBook, we hope to open up a discussion among athletes, coaches, and trainers as to the different ways Muscle Oxygen Monitoring can be used to guide the training of triathletes specifically, and elite athletes generally. This requires a starting point, or initial framework, from which a discussion can evolve. In building such a framework, we've taken the liberty of making two basic assumptions which we believe hold true for most, if not all, elite athletes:

1. They have one primary fitness performance goal.
2. Inducing certain physiological adaptations will help them achieve this goal.

Presuming these two assumptions are valid, after clarifying their primary goal, each athlete must identify which physiological adaptations are most useful, and then clarify which training parameters offer the greatest chance of inducing these adaptations.

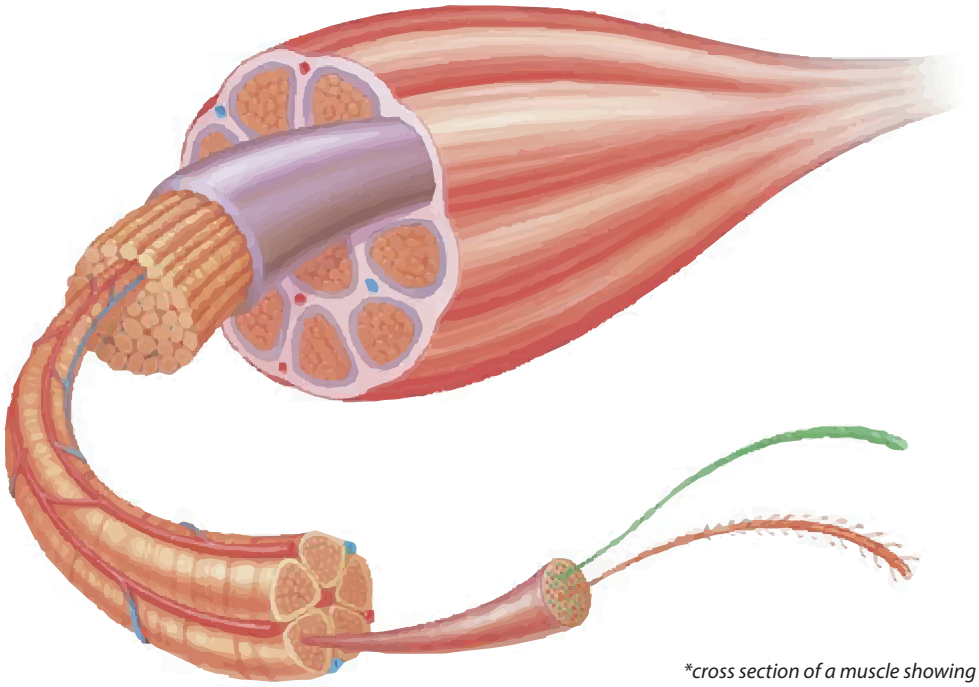
Within this framework, we believe Muscle Oxygen Monitoring can help athletes in two ways: 1) by identifying the most useful physiological adaptations, 2) by providing accurate, personalized training guidance to efficiently bring about these adaptations.

To add substance to this framework, we've created a fitness profile for a hypothetical triathlete. We will examine how this triathlete can use Muscle Oxygen Monitoring to optimize the effectiveness of his high-intensity interval training (HIIT, or HIT) regimen, and in so doing achieve his primary goal of inducing muscle-skeletal adaptations to increase endurance performance.

Before we go further, though, here is a brief review of the concept of physiological adaptation as it relates to fitness.

WHAT IS A PHYSIOLOGICAL ADAPTATION?

In a biological sense, a physiological adaptation is generally narrow in scope and involves response of an individual to a particular range of stimuli.[1] A physiological adaptation is distinguished from a trait in that it provides a functional response or solution to a specific problem; the environment presents problem for an organism that a physiological adaptation resolves. In this sense, physiological adaptation is a process rather than a physical aspect of the body.



*cross section of a muscle showing fibers

With regard to human fitness, adaptation refers to the body's physiological, or functional, response to physical training. The purpose of physical training is to put enough systematic stress on the body to improve its ability to exercise and induce desired physiological adaptations. If the stress is not sufficient, no adaptation occurs; if the stress is too high, the body runs the risk of overtraining and injury.

Significant improvements in athletic performance occur when athletes follow training parameters or regimens that most efficiently induce desired physiological adaptations; these parameters can be identified, and their effectiveness measured, with techniques such as Muscle Oxygen Monitoring.

USING MUSCLE OXYGEN MONITORING TO IDENTIFY DESIRED ADAPTATIONS

Let's get back to our original question relating to how our hypothetical triathlete can use Muscle Oxygen Monitoring to guide his training.

FITNESS PROFILE

Athlete: Competitive Triathlete

Primary Goal: Improve Endurance Performance

Desired Physiological Adaptation: Muscle-skeletal: Increase muscle oxidative capacity

Training Regimen: HIT

Measurement Technique: Muscle Oxygen Monitoring

Monitoring Tool: Moxy Muscle Oxygen Monitor

USING MUSCLE OXYGEN MONITORING TO IDENTIFY DESIRED ADAPTATIONS

To get started, we must ask a series of questions:

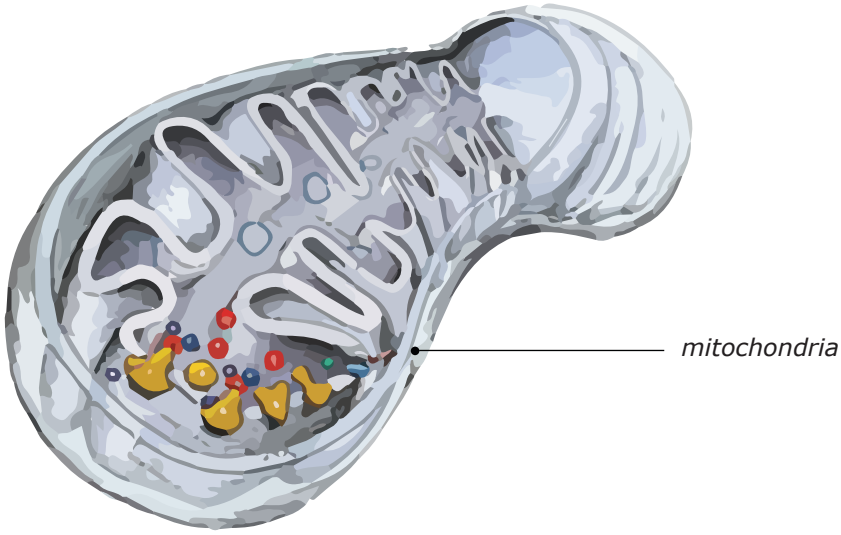
- What is our triathlete's primary fitness goal?
- Which physiological adaptation* is most likely to achieve his goal?
- What tools/techniques can help identify this adaptation?
- Which training regimen can best induce this adaptation?
- What tools/techniques can improve the efficiency of this training regimen?

*We recognize that certain athletes may require multiple adaptations to fulfill a fitness goal; for the sake of clarity, we have decided to focus on a single adaptation throughout this eBook

Knowing our triathlete's primary fitness goal is to improve endurance performance, but is time bound by job and family obligations, it is first necessary to identify which physiological adaptation is most likely to achieve his primary goal.

IDENTIFY DESIRED ADAPTATIONS CONTINUED...

In a 2008 study, Gibala and McGee concluded that High-Intensity Interval Training (HIIT, or HIT) is a very time-efficient strategy to induce adaptations normally associated with endurance training; these adaptations included rapidly improved exercise capacity as well as increased muscle oxidative capacity related to mitochondrial function.[2] As {Seiler} points out, oxygen consumption = Cardiac output x arterial-venous oxygen difference (a-v O2 diff). As oxygen rich blood passes through the capillary network of a working skeletal muscle, oxygen diffuses out of the capillaries to the mitochondria. The higher the oxygen consumption rate by the mitochondria, the greater the oxygen extraction, and the higher the a-v O2 difference at any given blood flow rate.[3]

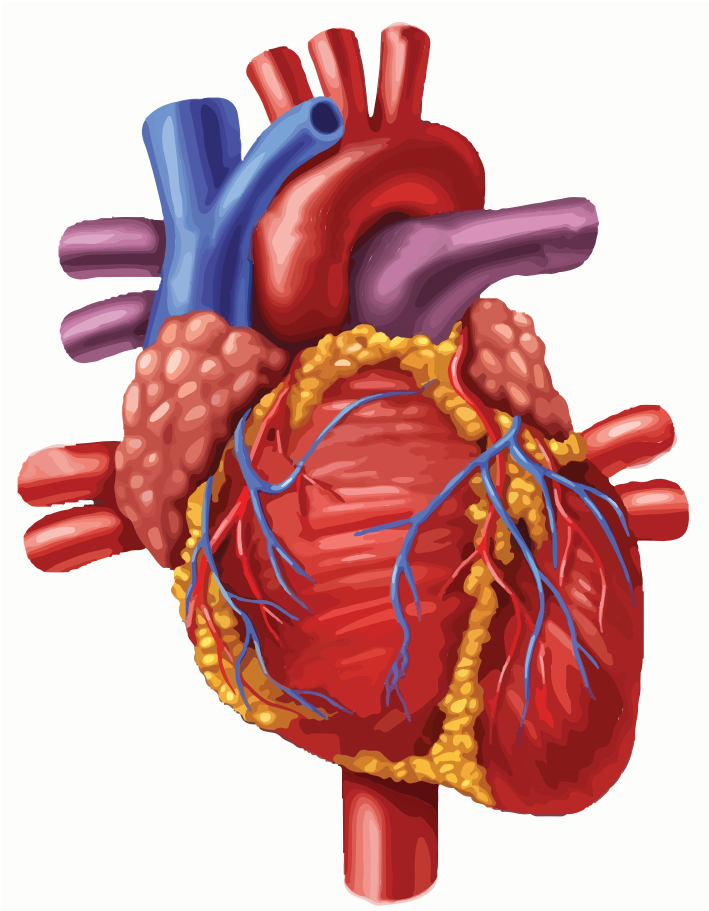


Put another way, HIT stimulates mitochondrial production. More mitochondria improve oxidative capacity. More oxidative capacity increases the a-v difference. A higher a-v difference increases VO2 max (i.e. the athlete can do more work). These processes conspire to improve endurance performance.

How can Muscle Oxygen Monitoring be used to help identify if an athlete might benefit from training that induces muscle oxidative capacity? We have seen anecdotally that more fit athletes have a faster reduction in muscle oxygenation at the onset of exercise than less fit athletes or non-athletes. Can we develop a test that quantifies an athlete's oxidative capacity? If it is already high, there might be little benefit in in pursuing an intense HIT protocol like that described by Gibala and McGee. If there is room to improve oxidative capacity, then a significant increase in exercise capacity could be expected with a few weeks of modified training.

IDENTIFY DESIRED ADAPTATIONS CONTINUED...

We should also consider which adaptive system is the limiting one. Juerg Feldmann, Head of Sports Science at **FaCT Canada**, has developed the concept that several of the adaptive systems in the body work together, but for a given exercise and a given athlete, one system will be the limiter. For example, a weightlifter is limited by the muscular system while having excess cardiac and respiratory capacity, whereas a runner might be limited by the cardiac system.



In identifying the limiting system, we can contemplate adaptations to improve the capacity of that system, or offload from a limited system to one with excess capacity. If the cardiac system is limiting, improved oxidative capacity leading to better oxygen extraction would get more oxygen delivered without increasing cardiac capacity. If the respiratory system is limited by high altitude, then metabolic capacity might not be the most important factor.

USING MUSCLE OXYGEN MONITORING TO INDUCE DESIRED ADAPTATIONS AND GUIDE TRAINING

Once we've decided that we want to improve our triathlete's oxidative capacity and mitochondrial function, what role does Muscle Oxygen Monitoring play? Muscle Oxygen Monitoring has the potential to help on both the input and output sides of this equation. On the input side, it can be used to monitor the exercise intensity of specific muscles in real time. Perhaps it can be used on the output side as well to help quantify oxidative capacity, as suggested above.

Within our initial framework, we can use Muscle Oxygen Monitoring to quantitatively identify individual HIT parameters for our triathlete, and then develop training guidance to optimize results. At this point it is important to recognize that there is no universal definition of "low" and "high" intensity levels; rather, these metrics are variable to each athlete. Most athletes and coaches know that HIT is beneficial on some level, but without a standard measurement to discern the precise benefit to the individual athlete, it is difficult to create truly effective HIT training guidance. For example, an unfit individual with a low oxidative capacity would likely require a vastly different HIT regimen than a fit individual with a high-oxidative capacity. Muscle Oxygen Monitoring can help identify and quantify both the low and high intensity interval levels, providing the individual athlete personalized and accurate training guidance, regardless of his or her fitness level.

CONCLUSION

In conclusion, we submit the hypothesis that the effectiveness of HIT in improving oxidative capacity is at least partially dependent on the precision of the high and low intensity levels at which the individual athlete trains.

Muscle Oxygen Monitoring with a device such as Moxy Monitor can help quantify HIT levels at both the high and low end, giving athletes, coaches, and trainers the unique ability to create accurate and personalized HIT training regimens. In the case of our triathlete, Muscle Oxygen Monitoring would help him more efficiently achieve his primary goal of improving endurance performance by increasing muscle oxidative capacity.

MOXY

MUSCLE OXYGEN MONITOR

WHAT IS MOXY MONITOR?

Fortiori Design has developed the Moxy Muscle Oxygen Monitor system to measure the oxygen levels of muscles in athletes while they exercise. Its accurate, real time measurements are fundamental to athletic performance. Oxygen is the fuel that drives the muscles, and muscle oxygen levels are constantly changing with exercise intensity.

Moxy provides the feedback on exercise intensity that athletes are looking for. Our technology is superior to existing measurements because it is completely mobile, continuously recording, and totally non-invasive.

WHY MOXY MONITOR?

Moxy is **Accurate**: Its sensor utilizes cutting-edge medical device technology to produce accurate and consistent readings of SmO2 muscle oxygen levels.

Moxy is **Easy** to Use: Its small sensor and strap can be easily fitted to measure virtually any muscle group.

Moxy is **Durable**: Its waterproof, lightweight industrial design is built to withstand the rigors of elite training.

Moxy is Fully **Mobile**: Sensor data is displayed on a wristwatch, so athletes can monitor their muscle oxygen throughout each workout.

Moxy is **Affordable**: With a price point similar to a GPS heart rate monitor, it is accessible to individual athletes.

SOURCES

[1] Biology Online, http://www.biology-online.org/dictionary/Physiological_adaptation

[2] Gibala and McGee, "Metabolic Adaptations to Short-term High-Intensity Interval Training: A Little Pain for a Lot of Gain?"

[3] Seiler, "EXERCISE PHYSIOLOGY, The Methods and Mechanisms Underlying Performance"