Physiology Primer for Triathletes

By Edward Yah, MSc

Introduction

Every triathlete will concur that a major determinant of his personal record time is that of the duration and magnitude of muscular fatigue experienced during the race. As a result, it is important for endurance athletes to understand the physiological adaptation to the aerobic system and how to better manage these physical limitations, in order to improve on their performance.

This article will attempt to explain the physiology behind why an athlete would experience muscular fatigue during and after training and competitions. From there, we will also discuss some of the strategies in which triathletes can take to recover from muscular fatigue faster and more effectively.

Introduction to Triathlon

Triathlon is an endurance sport, consisting of a combination of three distinct sports all rolled into one consecutive event.

It consists of swimming, cycling and running back-to-back. The race time is determined from the total time it takes from start to finish inclusive of the "dead-time" between each leg, where the athlete will have to change their clothes and shoes to participate in the next leg (i.e. from swimming to cycling.)

Ever since the first swim-bike-run event was organised by the San Diego Track Club in 1974 and the first ironman distance triathlon in Hawaii in 1978. There is currently four common distances for triathlon around the world: Sprint, Olympic, Half Ironman, and the Ironman.

Aerobic Conditioning for Triathlon

To gain performance in triathlon performance triathletes often perform slower paced endurance-type training for a period of time, in order to improve their aerobic endurance. This type of aerobic conditioning is also known as "base training".

The main purpose of base training is to cause muscular adaptation to improve oxygen uptake and transportation to the muscles, and to increase the lactate threshold, so that rate of lactate removal can be increased, as well as to increase the overall energy production and utilisation.

Base training will help to train your body to be more efficient at breaking down and utilising fat (a primary energy source for the aerobic energy system) as an energy source. The benefits of aerobic training adaptation includes an increase in stoke volume of the heart, capillary density, and mitochondrial density.

According to Russ (2005), "Stroke volume increase simply means that your heart pumps more blood per beat. Mitochondria are structures within muscle cells that produce energy from fat and carbohydrate oxidation[…]Regular endurance training can double these structures (1). By increasing capillary density we can effectively transport more blood to the working muscles. The process of building capillaries occurs gradually. Because high stress training breaks down capillaries, base training is best for allowing the slow growth of capillaries."

Physiology of Muscular Fatigue

Muscle fatigue is described as a general feeling of the body unable to continue on with an exercise. Several factors may play a part in this phenomenon, including but not limited to, the mechanism, of hydronium and calcium ions in muscle cells during physical exertion. (Mac, 2010)

Adenosine triphosphate (ATP) is the primary energy source for muscles. And during intense activities, the anaerobic pathway provides the energy source needed to sustain the activity. The ATP-CP pathway store is limited to approximately 10 seconds and the Anaerobic Lactic to about 2 minutes, the aerobic pathway would therefore be the idea source of energy for triathletes, since it is able to produce ATP through the breakdown of glucose and glycogen in the presence of oxygen to the muscles in enough quantities to sustain the process.

A by-product of the breakdown of glucose and glycogen is lactate and hydronium ions. Once the supply of oxygen is reduced due to the body's ability to receive enough oxygen to meet its demand for the working muscles, the hydrogen ion concentrations increase resulting in an increased acidity level of the blood and muscle.

Due to this acidic environment, nerve signals from the brain to muscle fibres may get blocked. In the case of a triathlete, the buck of signal blockage would happen to the leg muscles, so it begins to feel heavier to move, and thus slowing down movement patterns, in order to allow more oxygen into the working muscles to start energy production via the aerobic system again.

Bellinger et al. (2008) postulates that muscle fatigue resulting from long intense exercise, may in fact be caused by tiny leaks of calcium inside muscle cells. The authors found that after high intensity exercise, like three hours of cycling by experienced cyclists, would result in the small channels within the cyclist's muscle cells to leak calcium. This leak weakens muscle contraction and stimulates a specific enzyme to attack muscle fibres, resulting in muscle fatigue. Fortunately, these leakages stop after a few days of rest.

There are generally two dominant forms of fatigue in sports. They are namely; short-term intense exercise induced fatigue, and extended sub-maximal training fatigue. Though the physiological cause of these fatigues are completely different, their resulting reduction in muscular performance is relatively similar. (Dalleck & Kravitz, n.d.)

1. Short-term, Intense Sport and Exercise

During vigorous exercise bouts like sprinting and short burst interval training (HIIT), continued muscular contraction, the primary energy source for these activities is ATP. Hence, under these highly demanding conditions, creatine phosphate which helps in resynthesizing ATP, together with glycolysis (breakdown of glucose) are the primary channels for maintaining ATP levels.

Since this continued cycle would soon be outpaced by the body's demand for ATP under these demanding physical exertions, and to prevent ATP deficiency, the process of glycolysis increases. As a result, the by-product of glycolysis – lactate and protons (believed to increase fatigue level) is henceforth increased as well.

Furthermore, it is also believed that due to proton accumulation, results in the decreased cellular pH of the muscles through a process known as acidosis, which in turn impairs muscle contraction through various mechanisms. This has been compared to be akin to the cellular regulation of sodium and potassium during muscle contractions, resulting in muscular contraction impairment caused by the increased acidity from proton accumulation. (Dalleck & Kravitz, n.d.)

2. Extended, Sub-maximal Sports and Exercise

Similar to the previous type of activities, activities that involves prolonged exertions like cycling and distance running type of muscle contractions, the body's ability to continuously regenerate ATP through its metabolic pathways is the weakest link in relation to its ability to sustain itself – from fatigue.

In such cases, the process known as "mitochondrial respiration" becomes the primary supplier of the much needed ATP. Although there may be many fuel sources that could be utilised for mitochondrial respiration, the two most important sources in relation to fatigue level are blood glucose and muscle glycogen. Although triglycerides (fats) are available for ATP production, as the duration required for its breakdown is much slower than glucose and glycogen.

Dehydration is also another factor for fatigue. Insufficient hydration and fluid loss will impair bodily temperature control systems and cardiovascular functions.

A by-product of muscle contraction is the continual release of body heat, which may result in hyperthermia. Fitts (1994) suggests that research shows hyperthermia causing a rise in body core temperature may lead to fatigue in both contracting muscles and the central nervous system.

An imbalance in body fluid during prolonged activities may result in a lowered level of blood flow to both the active muscles as well as the skin to dissipate heat. The resulting dehydration may increase heart rates and stresses the cardiovascular system further due to decreased blood volume (blood is 50% water). Therefore rehydration and fluid intake is extremely important in any prolonged sporting activity.

Fatigue Recovery Strategies

Goldsmith (2001) proposed a series of "fatigue factors" that may help a triathlete identify when they are in a state of fatigue that requires time to rest and recover.

All forms of training, especially triathlon training, produce stresses and strains on the athlete's body. So, knowing when the body needs a much deserved rest is vital in improving performance and prevents disaster from striking.

Some of Goldsmith's Fatigue factors include:

Sleep – Quality of sleep often indicates whether one is in a state of excessive fatigue. If so, the common symptoms include difficulty falling and staying asleep.

Muscle Soreness – It is normal for muscles to feel sore after training. However, if the soreness persists after 24 hours, it is an indication of excessive fatigue.

Resting Heart Rate – As ones fitness levels improve and/or gets accustom to regular training, the resting heart rate should get lower. However, it is suddenly gets elevated by 10-15 beats per minute for two to three consecutive days, it may mean the body is not recovering well from the training.

Energy – Individuals who train regularly should feel energetic and alert. When one begins to feel slow and lethargic, it may be an indication of overtraining,

Weight Loss – A regularly training athlete should be within an energy balance state, where there is neither drastic weight gain nor loss. However, in a fatigue state, body weight can fluctuate by 1 to 1.4 kg (or more) in a 24 hour period.

Recovery techniques – Few ways to combat fatigue is to use proper recovery techniques. Including eating a nutritionally balance diet for an active lifestyle, rehydrating adequately throughout the day, getting sufficient quality sleep, and doing some non weight bearing cross training like non-competitive mountain biking just for the fun of it.

***"Feel"* in the water** – Feeling off and experiencing a loss of water-sensitivity may be an indication of fatigue.

Stress – Stress can not only come from the training, but may also come from personal life, like relationship, money, work, etc. There is a strong relationship between life stress and fatigue levels which need to be considered in the overall total stress load a triathlete is experiencing.

Conclusion

In closing, it should be reiterated that one fundamental requirement for succeeding in the sport of triathlon is the understanding of the concept of fatigue management and how to overcome fatigue when it does happen eventually.

This article serves only as a short synopsis on the currently accepted notion of fatigue recovery for triathletes and should not be viewed as the only way to training for success. For best results, the reader is recommended to consult a competent triathlon coach for proper coaching, and/or consulting the vast resources available from their national triathlon associations.

About the Author

Edward Yah is a Master Fitness Instructor certified through the IFA, and holds a graduate diploma in Sports and Exercise Science from Republic Polytechnic in Singapore. Edward hopes to bridge the gap between theoretical frameworks and the practical application of sports science to the benefit of both the recreational and professional athlete. A marketing communications consultant by profession, Edward also holds a BA in Communication from the University of South Australia, and an MSc in Marketing from the National University of Ireland, Dublin. Edward can be contacted at edyah@edyah.com.

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