LifeQ

LifeQ solution for estimating EPOC

Version 1.0

Table of contents

Summary

- Excess post-exercise oxygen consumption (EPOC) returns the body to homeostasis after exercise to compensate for the oxygen deficit caused by a delay in increased oxygen consumption at the onset of exercise. Continuous monitoring of EPOC during an exercise session can prevent over-training.
- The gold standard for EPOC measurement is an expensive, time consuming indirect calorimetry test performed in a laboratory, making it unsuitable for frequent or continuous monitoring and inaccessible to most.
- The *LifeQ estimated EPOC solution v1.0* estimates continuous real-time EPOC during exercise with a mean percentage error of 23,8% compared to the gold standard indirect calorimetry measurement.

Key terms

- **Excess post-exercise oxygen consumption (EPOC) =** a quantifiable increase in oxygen consumption during recovery from exercise (ml/kg of body weight). This value will be highest at the end of a long strenuous workout and decays over time.
- **Recovery =** the period after exercise when the body returns to homeostasis.
- **Overtraining =** excessive exercise with insufficient recovery time, causing physiological stress and physical trauma.
- **VO_2 max** = maximum volume of oxygen that can be utilized in the body (typically measured during maximum exertion exercise).
- **Indirect calorimetry =** the method of using gas exchange measurements (oxygen consumption, carbon dioxide production) to determine type and rate of macronutrient utilization.

Introduction

At the onset of exercise of any intensity, energy demands rise rapidly to above resting levels. The anaerobic intramuscular energy system provides the immediate energy required until oxygen consumption (VO_2) has increased sufficiently to reach a steady state that can support aerobic energy production. The delay in increased VO_2 at the onset of exercise is known as the oxygen deficit. To compensate for the oxygen deficit, the body returns to resting state homeostasis following exercise via various physiological processes such as hemoglobin re-oxygenation, phosphagen store replenishment, lactate removal, restoration of muscle glycogen stores, hormone balancing, and cellular repair. This phenomenon is known as excess post-exercise oxygen consumption (EPOC)[1].

Traditionally, EPOC is determined using data from indirect calorimetry requiring a trained technician and specialized equipment in a laboratory setting to measure respiratory gas exchange and heart rate. Measured VO_2 is plotted against time and EPOC determined by quantifying the area between resting VO_2 and the VO_2 recovery period (Figure 1A). This method was used as the gold standard measurement for EPOC in this validation study.

Determination of EPOC from indirect calorimetry data requires the analysis of the data from an entire exercise session, including recovery VO_2 data. It is therefore not possible to determine the EPOC at various stages during an exercise session (for example at point A and B in Figure 1A).
In order to predict over training or over-exertion, a solution is required for

continuous, real-time estimation of EPOC throughout an exercise session, which the *LifeQ estimated EPOC solution v1.0* allows (Figure 1B).

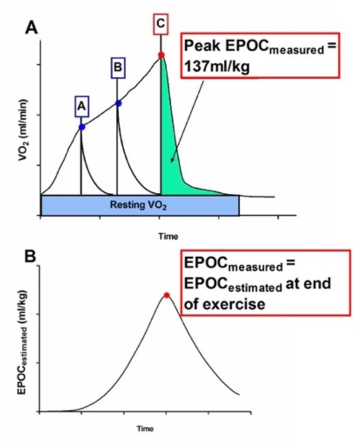

Figure 1: (A) Measured EPOC (area under VO_2 recovery period) in ml/kg from a typical increasing intensity exercise period and subsequent rest period. (B). The red dot indicates peak EPOC values.

Test Protocol

This validation study included 107 participants with a mean age of 33.5 years (21.0, 32.0, 48.0)*, 38 of which were female and 69 male, with a mean BMI of 27.1 (19.4, 25.2, 37.8)*. Participants were subjected to a VO_2 max protocol during which the following data was collected using an ECG chest strap heart rate monitor (BioHarness™) and a metabolic cart:

- Resting heart rate
- Continuous heart rate
- Resting VO_2
- Continuous VO_2 during VO_2 max test and recovery period

The VO_2max protocol entailed walking on a treadmill at a speed of 1km/h, with incremental speed increases of 1km/h each minute up to 8km/h after which the speed increased by 1 km/h every three minutes, until the participant reached exhaustion. Subsequently, the participants were required to rest for a period of 25 minutes during which the collection of respiratory gas exchange was continued. For validation purposes, EPOC estimations obtained by the *LifeQ estimated EPOC solution v1.0* were compared to the gold standard EPOC determination.

Results

A mean VO_2 max of 41.5 ml/min/kg (22.4, 43.1, 59.8)* was determined across the 107 participants who were further categorized into three groups:

- Uncategorized (BMI<30, non-athletes) (A)
- High BMI (BMI>30) (B), and
- Athletic (C)

The mean absolute % error (MAPE) of the *LifeQ estimated EPOC solutions v1.0* compared to the gold standard across these groups are summarized in Table 1 with the smallest error recorded in athletes.

Table 1: MAPE distribution of the *LifeQ estimated EPOC solutions v1.0* compared to the gold standard determination across three categories.

	Uncategorized n=56 (BMI<30, non-athlete) (A)	**High BMI n=35 (BMI>30) (B)**	**Athlete n=16 (C)**
MAPE(%)	22.9 (1.4,17.5,63.0)*	26.9 (3.7,22.3,70.8)*	20.8 (5.8,20.9,37.8)*

* (5th percentile, median, 95th percentile)

*(5th percentile, median, 95th percentile)

When the estimations of the *LifeQ estimated EPOC solution v1.0* were compared to the measured EPOC determined with the gold standard indirect calorimetery method, the MAPE was 23,8% (23.5, 19.6, 65.6)[*] with an R-value of 0.75 at the point of exhaustion (Figure 2).

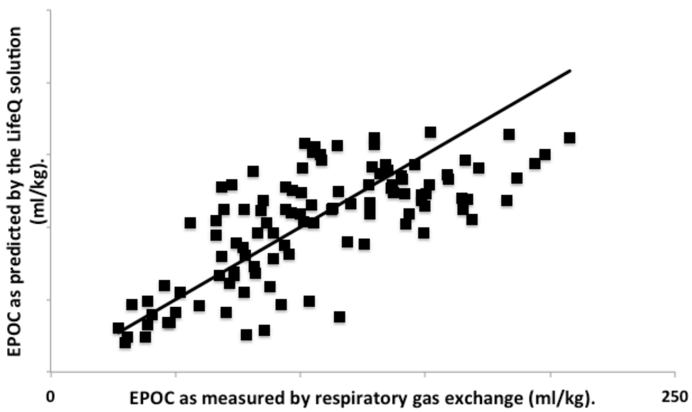

Figure 2: Correlation between EPOC values as determined by the *LifeQ estimated EPOC solution v1.0* and the gold standard indirect calorimetry method.

In addition, the *LifeQ estimated EPOC solution v1.0* allows monitoring of EPOC decline during exercise recovery, thereby allowing an individual to ensure full recovery before their next exercise session. This decline in EPOC after maximum exhaustion is illustrated at the hand of a single data set in Figure 3 with (A) showing the the decline in EPOC as determined by respiratory gas exchange (gold standard indirect calorimetry method), and (B) showing the decline in EPOC as estimated by the LifeQ solution.

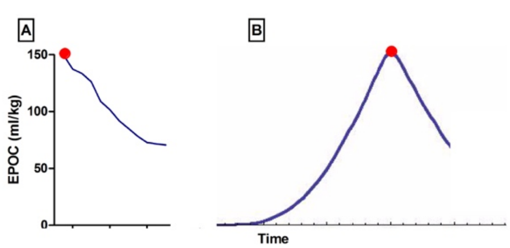

Figure 3: Comparing the decline in EPOC following the point of maximum exhaustion (red dot) as determined by (A) respiratory gas exchange and (B) the *LIfeQ estimated EPOC solution v1.0* for a single data set.

Conclusion

The *LifeQ estimated EPOC solution v1.0* allows continuous real-time estimation of EPOC, which can contribute towards the optimization of exercise intensity and duration for the prevention of over-training. By monitoring EPOC, valuable assessments can be made regarding an individual's cardiorespiratory fitness levels[2] for example, with improved cardiorespiratory fitness, a decrease in EPOC buildup as well as a shorter recovery time is typically observed[3]. Furthermore, EPOC may provide insight into how an individual responds to a specific exercise regimen, the level of effort required to increase fitness without over-training, as well as non-normative EPOC values used to indicate illness or over-training[4,5].

References

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[5] Matsuo, T., Ohkawara, K., Seino, S., Shimojo, N., Yamada, S., Ohshima, H., Tanaka, K. and Mukai, C., 2012. Cardiorespiratory fitness level correlates inversely with excess post-exercise oxygen consumption after aerobic-type interval training. *BMC research notes*, 5(1), p.646.