LifeQ VO_2 solution

Version 1.0

LifeQ

Table of contents

Introduction 2
Test Protocol 2
Results 3
Conclusion 4
References 4

Summary

- Oxygen consumption (VO_2) is a measure of the volume of oxygen that the body uses to convert energy sources to adenosine triphosphate (ATP) for use on cellular level.

- The gold standard for VO_2 measurement is an expensive, time consuming indirect calorimetry test performed in a laboratory, making it unsuitable for frequent or continuous testing and inaccessible to most.

- The *LifeQ VO_2 solution v1.0* estimates continuous VO_2 during various levels of activity; during rest and graded exercise with a mean % error of 23,6% and 17,3% compared to the gold standard measurement.

Key terms

- **VO_2 =** rate of oxygen consumption in the body in ml/min/kg
- **Indirect calorimetry =** the method of using gas exchange measurements (oxygen consumption, carbon dioxide production) to determine type and rate of substrate utilization
- **VO_2 max** = maximum rate at which oxygen can be utilized in the body (typically measured during maximum exertion)
- **Body Mass Index (BMI)** = derived from the weight and height of an individual (kg/m^2) and serves as an indication of body composition.

Introduction

Measurement of VO2 provides insight into an individual's aerobic activity, which is informative for sports/fitness; training progress, as well as rehabilitation treatment[1,2]. Furthermore, aerobic capacity has been found to correlate strongly with life expectancy, and serves as a robust, independent indicator of cardiovascular and all-cause mortality[3,4,5,6].

Traditionally VO_2 is measured in a laboratory setting by trained technicians and involves indirect calorimetry techniques whereby respiratory gas exchange is measured using equipment such as a gas masks and metabolic carts. While this is considered the gold standard method for measuring VO_2, it is time consuming, expensive, not conducive to frequent or continuous monitoring and inaccessible to most.

The *LifeQ VO_2 solution v1.0* estimates continuous VO_2 based on measured heart rate (HR) combined with other physiological parameters during various levels of activity including periods of rest, exercise and post-exercise recovery.

Test Protocol

This validation study included 108 participants with a mean age of 33.3 years (21.0, 32.0, 48.0)*, 34 of which were female

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

LifeQ

and 74 were male. The mean BMI was 27.0 (19.4, 25.2, 37.8)*, and the mean VO_2 max was 42.0 ml/min/kg (24.0, 34.2, 59.8)*. The following physiological parameters were collected for each participant:

- Height (m)
- Age (yrs)
- Weight (kg)
- Gender
- Resting heart rate (beats per min)
- Actual (measured by indirect calorimetry) VO_2 max (ml/kg/min)

Based on these physiological parameters, a user specific heart rate - VO_2 relationship was generated by the *LifeQ VO_2 solution v1.0* that enabled real time VO_2 to be estimated during rest (including supine, sitting and standing positions) and graded exercise.

The *LifeQ VO_2 solution v1.0* was compared to the gold standard laboratory based VO_2 measurements obtained using indirect calorimetry during rest and graded exercise, and the accuracy determined as follows and expressed as a mean absolute percentage error (MAPE).

$$MAPE = \frac{100}{N} \times \sum_{VO2=1}^{N} \left| \frac{(measured\, VO_2) - (predicted\, VO_2)}{measured\, VO2} \right|$$

Where N = the number of datasets in the study.

Results

The accuracy of the *LifeQ VO_2 solution v1.0* estimations compared to the gold standard measurements are summarized in Table 1.

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

Table 1: Mean absolute percentage error of the *LifeQ VO_2 solution v1.0* estimations compared to gold standard measurements during rest, and during graded exercise & recovery.

	Accuracy during rest	Accuracy during graded exercise & recovery
MAPE (%)	**23.6** (2.0, 20.2, 51.5)*	**17.3** (0.9, 10.9, 52.1)*
Correlation (R)	**0.980**	**0.972**

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

A small group of outliers (n=3) was identified in the collected data. These were found to be low-lung function participants, who displayed a MAPE of 31.2%.

Participants were further categorized into three groups:

- uncategorized (BMI<30, non-athletes) (A)
- high BMI (BMI>30) (B), and
- athletic (C)

Athletes were classified according to their VO_2 max, age and sex [7]. Uncategorized participants displayed a relatively low MAPE of 15.6%, whereas high BMI and athletic participants displayed MAPEs of 21.3% and 20.2%, respectively (Table 2).

Table 2: MAPE distribution between estimated and measured VO_2 values in uncategorized, athletic and high BMI participants during rest, and during graded exercise & recovery.

	Uncategorized (A)	High BMI n=32 (B)	Athlete n=16 (C)
MAPE Rest (%)	**20.6** (1.6, 17.3, 48.9)*	**35.6** (2.2, 23.4, 78.6)*	**28.8** (2.4, 22.0, 61.0)*
MAPE Exercise, recovery (%)	**15.6** (0.9, 10.2, 47.6)*	**21.6** (1.3, 14.2, 62.6)*	**20.2** (0.7, 9.3, 64.2)*

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

LifeQ

Conclusion

The *LifeQ VO_2 solution v1.0* provides a continuous estimate of VO_2 which can be applied to enable individuals to improve their wellness and athletic ability. Furthermore, aerobic capacity correlates strongly with life expectancy, and serves as a robust, independent indicator of cardiovascular and all-cause mortality. Aerobic capacity data can be used as a powerful tool in risk stratification and decision making in disease prevention and various clinical settings[8,9,10,11].

References

[1] Eriksen, L., Curtis, T., Grønbæk, M., Helge, J.W. and Tolstrup, J.S., 2013. The association between physical activity, cardiorespiratory fitness and self-rated health. *Preventive medicine*, 57(6), pp.900-902.

[2] Carnethon, M.R., Gulati, M. and Greenland, P., 2005. Prevalence and cardiovascular disease correlates of low cardiorespiratory fitness in adolescents and adults. *JAMA*, 294(23), pp.2981-2988.

[3] Katzmarzyk PT, Church TS, Blair SN. Cardiorespiratory fitness attenuates the effects of the metabolic syndrome on all-cause and cardiovascular disease mortality in men. *Archives of Internal Medicine*. 2004;164(10):1092-1097.

[4] Sui X, LaMonte MJ, Laditka JN, et al. Cardiorespiratory fitness and adiposity as mortality predictors in older adults. *JAMA.* 2007;298(21):2507-2516.

[5] Kodama S, Saito K, Tanaka S, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: A meta-analysis. *JAMA.* 2009;301(19):2024-2035.

[6] Cristi-Montero C. Considerations regarding the use of metabolic equivalents when prescribing exercise for health: Preventive medicine in practice. *The Physician and sportsmedicine.* 2016;44(2):109-3.

[7] Astrand, I., 1960. Aerobic work capacity in men and women with special reference to age. Acta physiologica Scandinavica. Supplementum, 49(169), p.1-92.

[8] Katzmarzyk PT, Church TS, Blair SN. Cardiorespiratory fitness attenuates the effects of the metabolic syndrome on all-cause and cardiovascular disease mortality in men. *Archives of Internal Medicine*. 2004;164(10):1092-1097.

[9] Sui X, LaMonte MJ, Laditka JN, et al. Cardiorespiratory fitness and adiposity as mortality predictors in older adults. *JAMA.* 2007;298(21):2507-2516.

[10] Kodama S, Saito K, Tanaka S, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: A meta-analysis. *JAMA.* 2009;301(19):2024-2035.

[11] Cristi-Montero C. Considerations regarding the use of metabolic equivalents when prescribing exercise for health: Preventive medicine in practice. *The Physician and sportsmedicine.* 2016;44(2):109-3.