LifeQ

LifeQ VO_2 max solution

Version 2.0

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Summary

- VO_2 max is the most frequently used measure of cardiorespiratory fitness
- The gold standard for VO_2 max measurement is an is an expensive, time consuming indirect calorimetry test performed in a laboratory setting, making it unsuitable for frequent or continuous monitoring and is inaccessible to most
- The *LifeQ VO_2 max solution v2.0* estimates VO_2 max using a single-stage submaximal VO_2 max test and heart rate, and does not require specialized equipment
- Estimations by the *LifeQ VO_2 max solution v2.0* shows a strong correlation with gold standard laboratory VO_2 max measurements of R = 0.901, with a mean absolute percentage error of 9.7%

Key terms

- **VO_2 max** = maximum volume of oxygen that can be utilized by the body (typically measured during maximum exertion exercise) in ml/min/kg.

Introduction

Maximal oxygen consumption (VO_2 max) refers to the maximum amount of oxygen utilized by the body per kilogram of body weight, per minute. VO_2 max is the most frequently used measure of cardiorespiratory fitness, and is a valuable tool in the calculation of other physiological parameters such as VO_2, energy expenditure and excess post exercise oxygen consumption.

The current gold standard for VO_2 max measurement requires a highly intensive laboratory-based test that demands maximal physical effort. The test consists of a graded exercise test (GXT) that typically uses indirect calorimetric techniques, requiring specialized and expensive laboratory equipment including a metabolic cart, gas mask, chest strap and treadmill (Figure 1), administered by a trained laboratory technician. The test requires the measurement of inhaled and exhaled gas concentrations while the exercise intensity is progressively increased to push the aerobic energy system to its maximal capacity. The highly specialized equipment and invasive nature of the laboratory based VO_2 max determination makes this method inaccessible to most.

The *LifeQ VO_2 max solution v2.0* uses a single-stage submaximal VO_2 max treadmill test, which requires heart rate (HR) measurements during a comfortable treadmill protocol, eliminating the need for an exhaustive exercise test and specialized equipment.

Figure 1: Example of a gold standard VO_2 max measurement using a treadmill, a metabolic cart, a chest strap HR monitor and a gas mask.

Test Protocol

The LifeQ VO_2 max test was validated against the gold standard laboratory-based VO_2 max GXT using indirect calorimetry. The LifeQ VO_2 max test and the gold standard laboratory-based VO_2 max test were performed on consecutive days, with the the gold standard laboratory-based VO_2 max test performed on the day after the LifeQ VO_2 max test.

This validation study included 126 participants with a mean age 33.5 years (21.3, 32, 49.5)*, 45 female and 81 male. The mean BMI was 26.8 (19.4, 25.2, 37.5)* and the mean VO_2 max was 41.5 ml/min/kg (23.4, 43.1, 59.0)*.

The following physiological parameters were collected for each participant:

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

For the LifeQ VO_2 max test HR was measured continuously using an ECG chest strap. Participants began with a 3-minute warm-up walk on a treadmill, followed by a jog at a comfortable self-selected speed between 7 and 12 km/h, at a pace that did not let the HR rise above 180 beats per minute for approximately 3 minutes (until a steady HR was achieved). Using the continuous ECG HR data, combined with the basic physiological parameters described above, a VO_2 max value was estimated for each participant using the *LifeQ VO_2 max solution*.

For the gold standard laboratory VO_2 max test, test participants were asked to refrain from caffeine and alcohol use less than 12 hours before the test, eating and drinking (except for water) less than 3 hours before the test and performing any exercise less than 24 hours before the test. Resting heart rate and VO_2 max were measured using a chest strap heart rate monitor, a BioHarness™ device, a gas mask and a metabolic cart. Following a resting protocol of 35 minutes, participants started walking on the treadmill at a speed of 1 km/h, which was incremented by 1 km/h each minute up to 8 km/h after which the speed was incremented only every 3 minutes, until the participant reached voluntary exhaustion. Respiratory gas exchange was monitored and VO_2 max was defined as the highest average VO_2 value over a 30 second steady-state period [1] (Figure 5).

* 5th percentile, median, 95th percentile

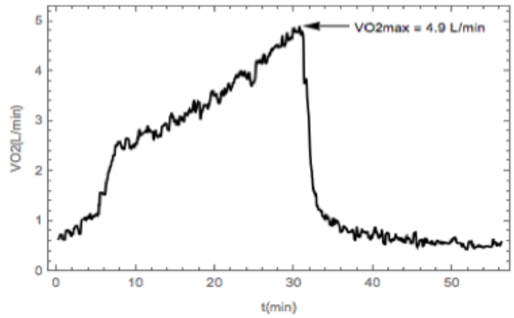

Figure 5: Oxygen consumption (VO_2) during an individual VO_2 max graded exercise test (GXT). The recorded VO_2 max is indicted by the arrow.

The *LifeQ VO_2 max solution v2.0* was compared to the gold standard laboratory based VO_2 measurements obtained using indirect calorimetry during graded exercise. The accuracy, expressed as a mean absolute percentage error (MAPE), was determined as follows:

$$MAPE = \frac{100}{N} \times \sum_{VO2max=1}^{N} \left| \frac{(measured\ VO_2max) - (predicted\ VO_2max)}{measured\ VO_2max} \right|$$

Where N = the number of datasets in the study.

Results

A comparison of the outputs of the *LifeQ VO_2 max solution v2.0* and the laboratory-based measured VO_2 max of each test participant is presented in Figure 6 with a correlation of R = 0.901 between the estimated and measured VO_2 max and a MAPE of 9.7% (0.4, 6.8, 28.8)*.

* 5th percentile, median, 95th percentile

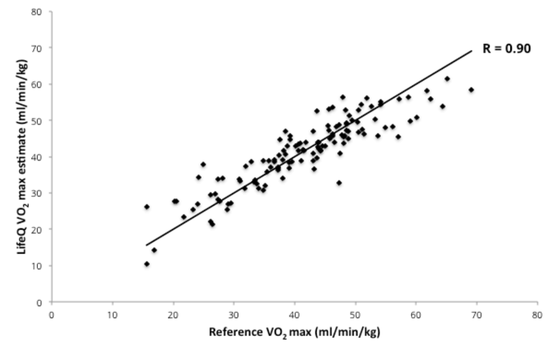

Figure 6: Scatterplot of the LifeQ estimated vs. laboratory based reference VO_2 max (ml/min/kg) values for 126 participants.

Participants were further categorized into three groups:

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

The MAPE across these groups are summarized in Table 1.

Table 1: Mean average percentage error distribution between predicted and reference VO2 max values in normal, elite athlete and high BMI participants.

	Uncategorized (A) n=74	High BMI (B) n=32	Athlete (C) n=16
MAPE Rest (%)	**6.7** (0.8, 5.4, 17.0)*	**15.9** (0.3, 10.4, 44.9)*	**9.7** (1.5, 9.7, 17.1)*

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

Conclusion

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[2,3,4,5]. The *LifeQ VO_2 max solution v2.0* provides an estimate of actual VO_2 max for better understanding of individual athletic ability, cardiorespiratory health and improved accuracy of other VO_2 max dependent calculated physiological parameters.

References

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