Validation of the Polar Fitness Test

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Abstract

Aerobic capacity testing can be beneficial to coaches, physical educators, and trainers in the process of designing aerobic training programs. However, testing in a laboratory can be costly. Polar heart rate monitors provide a fitness test that estimates aerobic capacity without having to use expensive equipment. The purpose of this study was to determine the efficacy of the Polar fitness test in comparison to the laboratory test. Eighteen college-age students completed the Polar fitness test along with a laboratory test for aerobic capacity. The laboratory test consisted of a maximal Bruce protocol treadmill test while the subject was connected to a metabolic cart. The study found that the Polar fitness test provides results that are not statistically different from the metabolic cart results ($t = 1.681$, $p = 0.111$). Additionally, the 2 tests were strongly correlated ($r = 0.545$, $p = 0.019$). This indicates that the Polar fitness test may be an appropriate means of aerobic capacity testing for those not needing the accuracy of expensive laboratory equipment.

Keywords: aerobic capacity, VO_{2max}, aerobic fitness assessment, Polar

1. Introduction

Maximal oxygen consumption, also referred to as aerobic capacity or VO_{2max}, is the maximum amount of oxygen that is consumed and used by an individual while they are in a maximal working state (Boone, p. 70). This measurement is typically obtained by conducting a maximal graded exercise test while a subject is connected to a metabolic cart (Beam, p. 164-166). Of the protocols available, the Bruce test is considered to be "by far the most popular" treadmill protocol (Neiman, p. 62). A treadmill and metabolic cart are needed to measure maximal oxygen consumption properly. The metabolic cart measures the oxygen consumption of the subject while the Bruce treadmill protocol pushes the individual to their maximal capacity (Beam, p. 164, 168). Measurement of oxygen consumption during maximal exercise stress provides a person's VO_{2max}.

The data that is collected from the metabolic cart is commonly used to define training zones for aerobic conditioning programs (Neiman, p. 180, Swain, p. 470-471). This information can also be used to determine which energy system an athlete's body is utilizing at a given work rate (Boone, p 269, Powers & Howley, p. 81). Knowing an athlete's VO_{2max} and energy system utilization allows coaches to specifically cater workout regimens to the sport for which the athlete is training and, therefore, create a more efficient workout.

Testing VO_{2max} via metabolic cart requires expensive equipment as well as a professional to operate the metabolic cart and supervise the test. This ensures the correct protocols are followed, and accurate data is being collected. However, the cost of a metabolic cart is often prohibitive as a device costs upwards of $20,000 (P. Yeh, personal communication, August 8, 2017). Many coaches, training facilities, and schools do not have large enough budgets to warrant this expense.

Several devices have been developed to assess fitness levels without using a metabolic cart. These include various Polar devices, Garmin fitness watches, Fitbit, Nike Fuelband, and others (Porcari, p. 105). Many such devices track fitness rather than truly assessing it. Polar is unique in that several of the Polar devices are programmed with a fitness test (www.polar.com). The Polar RS300X is one such device. It can be purchased on Amazon for ~$200, which is significantly cheaper than a metabolic cart. Additionally, the Polar fitness test does not require a technician for administration and supervision. Such fitness tests may be significantly more practical for many coaches, physical educators, and trainers. The purpose of this study was to evaluate the efficacy of the Polar fitness test as an alternative to aerobic capacity testing using a metabolic cart.

2. Methods

This study was approved by the Arkansas Tech University Institutional Review Board.

2.1 Subjects

Subjects were all students majoring in Health and Physical Education or Wellness Science at Arkansas Tech University. The subjects were recruited primarily from the PE 3661 Laboratory Experiences in Anatomy/Physiology and Kinesiology and the WS 1002 Wellness Fitness classes. Twelve male and 6 female subjects volunteered (n=18). The subjects were 21.3 (± 2.25) years of age. To ensure that all subjects were healthy enough to participate in the study, they were screened using the Physical Activity Readiness Questionnaire (PAR-Q). All subjects answered no to all items on the PAR-Q, meaning they were considered to be healthy enough for physical activity. Had any subjects answered yes to any items, they would have been excluded from the study until being cleared by a medical professional for physical activity.

2.2 Procedures

The study was conducted in the Human Performance Laboratory. Each subject reported individually for a single session. During this session, the subject completed all 3 phases of the study. Phase 1 consisted of paperwork and resting measurements. The Polar fitness test comprised Phase 2, while phase 3 consisted of a Bruce treadmill test with the subject connected to the metabolic cart.

For phase 1, each subject completed the informed consent process and the PAR-Q. Height, weight, and blood pressure were measured for each subject. The subject then began phase 2 and was fitted with the Polar heart rate strap according to the instructions provided by Polar (Polar RS300X User Manual, 2011, p. 13). The heart rate strap was paired with the Polar RS300X fitness watch, and the User Profile was set to match the subject.

The User Profile consisted of the subject's birthday, height, weight, sex, activity level, maximum heart rate and sitting heart rate (Polar RS300X User Manual, 2011, p 6). Polar uses an average of a person's physical activity over the past 3 months to determine activity level. Figure 1 shows the guidelines provided by Polar to determine an individual's physical activity level (How to Choose).

Figure 1 How to Choose the Right Activity Level in Polar Fitness Test

Activity level is an assessment of your level of long-term physical activity. Select the alternative that best describes the overall amount and intensity of your physical activity during the past three months.

- Top: You participate in heavy physical exercise at least 5 times a week, or you exercise to improve performance for competitive purposes.
- High: You participate at least 3 times a week in heavy physical exercise, e.g. you run 10-40 km/6-25 miles or you cycle 2-4 hours (40-120 km.25-75 miles) per week or spend that time in comparable physical activity.
- Moderate: You participate regularly in recreational sports, e.g. you run 5-10 km or 3-6 miles or you cycle ½-2 hours (15-40 km/3-25 miles) per week or spend that time in comparable physical activity, or your work requires modest physical activity.
- Low: You do not participate regularly in recreational sport or heavy physical activity, e.g. you walk only for pleasure or exercise hard enough to cause heavy breathing or perspiration only occasionally.

Maximum heart rate was determined by the standard calculation of 220-age (Boone, p. 128). Sitting heart rate was acquired based on the pre-test heart rate measured by the Polar device. The User Profile also requests the subject's VO_{2max}. However, this information was not yet known, so the predicted value was simply selected.

At this point, the subject was ready to begin the fitness test. The subject was instructed to lie down on the table in the lab. The fitness test was selected on the watch menu once the subject was in a comfortable position. The test began when the technician pressed start. The test simply required the subject to lie still for a 5 minute period. At the end of the test, the watch display showed the results as the OwnIndex (VO_{2max}). This number was recorded, and the Polar fitness test was complete.

Phase 3 began shortly after completion of the Polar fitness test once the subject's height, weight, age, gender, and race had been entered into the software for the Parvomedics TrueOne 2400 metabolic cart. Subjects were instructed that they were in charge of the test. If they signaled to end the test at any point in time, the test would end immediately. All subjects were encouraged to push themselves to their maximum capability in order to obtain accurate data.

At this time the subject was fitted with a facemask which was connected to the metabolic cart via an airtight hose. The subject straddled the belt of the treadmill until the belt was moving at the speed and grade for stage 1 of the Bruce protocol (see Table 1). The test began after the subject stepped onto the belt of the treadmill and was walking comfortably. The treadmill protocol used was the Bruce protocol (see Table 1).

This protocol consists of 3-minute stages where the speed and grade increase every 3 minutes. Heart rate was monitored continuously throughout the test as the subject was still wearing the Polar heart rate monitor. Blood pressure and rate of perceived exertion were measured in the final 30 seconds of each stage.

Table 1 Bruce Treadmill Protocol

Stage	Speed (mph)	Grade (%)	Duration (min)
1	1.7	10	3
2	2.5	12	3
3	3.4	14	3
4	4.2	16	3
5	5	18	3
6	5.5	20	3
7	6	22	3

In order to ensure the safety of all subjects, the American College of Sports Medicine (ACSM) guidelines for exercise test termination were followed. The absolute indications for test termination are:

- Drop in systolic BP of ≥10 mm Hg with an increase in work rate, or if systolic BP decreases below the value obtained in the same position prior to testing when accompanied by other evidence of ischemia
- Moderately severe angina (defined as 3 on standard scale)
- Increasing nervous system symptoms (*e.g.,* ataxia, dizziness, or near syncope)
- Signs of poor perfusion (cyanosis or pallor)
- Technical difficulties monitoring the ECG or SBP
- Subject's desire to stop (other than V_1 or aVR) (taken directly from ACMS's Guidelines for Exercise Testing, 2014, p. 131).

The relative indications for test termination are:

- Drop in systolic BP of ≥10 mm Hg with an increase in work rate, or if systolic BP below the same value obtained in the same position prior to testing
- Fatigue, shortness of breath, wheezing, leg cramps, or claudication
- Increasing chest pain
- Hypertensive response (SBP of >250 mm Hg and/or a DBP of >115 mm Hg (taken directly from ACMS's Guidelines for Exercise Testing, 2014, p. 131).

The electrocardiogram (ECG) guidelines were omitted from this list as ECG was not used during this test. The subjects were encouraged to continue the test until they obtained VO_{2max} which has been defined as the point where the subject's oxygen consumption leveled off regardless of an increase in workload (ACSM's Guidelines for Exercise Testing, 2014, p. 73). However, this leveling off does not occur for all individuals. Alternative criteria include: obtaining age-predicted maximum heart rate (HR_{max} = 220 – age) or obtaining a respiratory exchange ratio of 1.15 or greater (McArdle, Katch, Katch, 2015, p. 37). The trial was also terminated if the subject requested to stop. The test was brought to an end and the data saved when any of these criteria were obtained.

Upon completion of the treadmill test, the facemask was removed, and the subject began to cool down. The subject walked on the treadmill at a leisurely pace for 3 minutes followed by 3 minutes of sitting comfortably. Heart rate and blood pressure were monitored throughout this time. Subjects remained in the lab and were continuously monitored until their heart rate returned to below 120 bpm and their blood pressure reading returned to near normal.

2.2 Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics 23. Descriptive statistics were used to ensure that the data met the assumptions for the selected tests. The similarity of the data obtained from the 2 fitness tests was evaluated by a paired samples T-test. A 2-tailed test was used with a p-value set at 0.05 for statistical significance. A Pearson correlation coefficient was also used to determine the strength of the relationship between the two tests.

3. Results

VO_{2max} from the Polar fitness test was found to be 47.67 (± 9.56) ml/kg/min while the metabolic cart revealed a VO_{2max} of 44.09 (± 9.37) ml/kg/min. The data are presented in Table 2.

Table 2 Aerobic Capacity Data

Subject	Polar (ml/kg/min)	Metabolic Cart (ml/kg/min)
1	35	37.3
2	57	43.5
3	42	37
4	49	53.3
5	57	39.4
6	52	38
7	42	47.3
8	60	56.1
9	56	59.3
10	51	39.4
11	48	58.3
12	37	36.4
13	29	33
14	48	42.6
15	60	53.5
16	58	51.8
17	41	34.9
18	36	42.5
Mean	47.67	44.09

The paired samples T-test revealed no significant differences in the data obtained from the Polar fitness test compared to the data from the metabolic cart ($t = 1.681$, $p = 0.111$). The Pearson correlation evaluation revealed a correlation coefficient of $r = 0.545$ ($p = 0.019$) for the means of the two tests. This shows that the two methods for obtaining VO_{2max} are not statistically different from each other and, in fact, they are significantly correlated.

4. Discussion

The Polar fitness test was not found to be significantly different from the metabolic cart in terms of evaluating aerobic capacity. This indicates that the Polar fitness test may be an adequate means of assessing aerobic capacity. The Pearson correlation coefficient reveals more about the appropriateness of the Polar fitness test in that it was found to be 0.545. Miller labels a correlation of 0.3 - 0.7 as a strong correlation for the field of fitness and exercises science (Miller, 2012, p. 8). A correlation of 0.545 is right in the middle of the range defined by Miller as being a strong correlation. Thus, the Polar fitness test can be considered an appropriate tool for assessing VO_{2max}.

The Polar fitness test did tend to overestimate an individual's aerobic fitness level. The mean from the Polar test was 47.67 ml/kg/min, which was 3.58 ml/kg/min greater than the results obtained from the metabolic cart. Although this difference was not statistically significant, it would make a practical difference in any training plans built using this information. Individuals following a training plan built from the Polar results would potentially be working harder than they needed to be or that the plan intended. Practitioners should be mindful of the overestimation of fitness levels by the Polar fitness test.

There are a few strengths and weaknesses in this study. A strength of the study is that the subjects performed both tests on the same day. This means that there is less potential within-individual variability in the results. Most confounding variables would have impacted both tests equally. Another strength is that the statistical power was found to be quite high even though the number of subjects was relatively small ($n = 18$). When evaluated for statistical power, the study was found to have a power of 0.96, indicating that there is a 96% chance that the results are actually correct. A weakness might be that the subjects were permitted to self-select their activity level, potentially introducing bias and error into the results. Another weakness could be the imbalance of males and females in the sample size. Sex and age were not found to account for a significant amount of the variance in the data; however, this could be due to the relatively small sample size. In general, the strengths of this study seem to outweigh the weaknesses.

5. Conclusion

The Polar fitness test may be an appropriate tool to assess aerobic fitness levels in some settings. Practitioners choosing to use this assessment over other tools should keep in mind that the Polar test tends to overestimate a person's aerobic capacity. However, this should not prevent individuals from using the Polar fitness test if they find it to be appropriate for their setting otherwise.

The Polar fitness test is much cheaper to administer than the assessment using the metabolic cart. The Polar RSX300 watch used in this study can be purchased for under $200 on Amazon (https://www.amazon.com/Polar-RS300X-Heart-Rate-Monitor/dp/B00SB078ME). Other models of Polar watches programmed with the fitness test can be purchased for under $100 from Amazon (https://www.amazon.com/Polar-FT60-Heart-Monitor-White/dp/B00G40M6X4). In contrast to this expense, a metabolic cart is going to cost over $20,000 (P. Yeh, personal communication, August 8, 2017) and requires additional manpower to administer. The cost of a metabolic cart makes it far more inaccessible to most individuals than the cost of a Polar heart rate monitor/fitness watch.

The Polar fitness test is not an appropriate substitute for a metabolic cart when conducting research. However, the results from the Polar fitness test may be useful to sports coaches, strength and conditioning specialists, physical educators, personal trainers, amateur athletes and fitness enthusiasts. These individuals may not need the precision and accuracy of the results from a metabolic cart but could find the knowledge of aerobic capacity to be beneficial. This information could aid in designing training programs, monitoring the effectiveness of those programs, evaluating progress and even enhancing motivation. The Polar fitness test seems to be an appropriate, lower cost alternative to aerobic capacity testing using a metabolic cart.

Acknowledgement

The research was not financed or supported in any way by the Polar Electro.

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