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The Validity of VO₂max Testing Modalities in Running, Cycling and Swimming Populations

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Abstract

While it is generally accepted that the treadmill and cycle ergometer are equally valid modalities of testing maximal oxygen uptake (VO₂max) in athletes, the reasoning behind this assumption is largely unknown. Numerous studies have shown significant differences in VO₂max between various athletic populations due to the demands of their sport and training habits. As a result of these variances, the question has been raised as to how valid testing results are for different modalities in various athletic populations. Therefore, the purpose of the research project will be to determine the validity of two VO₂max testing modalities (treadmill and cycle ergometer) in swimming, running, and cycling populations. The main question this project aims to answer is which modality will provide a better measure of VO₂max for swimmers based on the differences between a whole body workout (treadmill) and a region specific workout (cycling). Fifteen healthy, untrained, college aged participants with experience in running, cycling or swimming took part in the study. Participants were randomized and completed two VO₂max tests (treadmill and cycle ergometer) on separate occasions. Results from individual participants testing will be analyzed to determine differences between modalities. Participants will be grouped by history of running, cycling or swimming and then results will be analyzed to determine significant differences between groups. Results from testing are forthcoming.

Introduction

While cycle ergometer and treadmill testing are widely utilized and are generally accepted as valid means of measuring VO₂max it remains unknown which modality is better suited for different populations of athletes such as runners, cyclists, and swimmers. VO₂max is the ability of the working tissues in the body to utilize oxygen during maximal exercise for energy production. While it is reasonable to infer that runners will be more proficient on the treadmill and cyclists on the cycle ergometer, it is unclear which modality is better suited for athletes such as swimmers when the option of swim testing is unavailable; as is often the case.

Previous studies, such as that of Sousa et al. (5) and Roels et al (6), have used specialized equipment for testing swimmers that is not widely available and therefore has limited application.

Other studies have also shown that estimating VO₂max using generalized prediction equations can be largely inaccurate (1,2).

The studies of Schembre et al (3) and Spackman et al (4) have displayed that large differences in recording VO₂max can also be caused by differences in procedures and protocols.

As a result of these studies we hypothesize that swimmers will produce more accurate measurements of VO₂max on the treadmill due to the whole-body nature of swimming compared to cycling and running.

Purpose

The purpose of this study is to determine which modality of exercise, running or cycling, would be the best predictor of VO₂max for running, cycling, and swimming populations.

Methods

Subject Selection:

15 male participants (18-22 yrs.) were recruited from Hope College Health Dynamics classes through email or in person. Participants were placed into either runner, biker, or swimmer groups based on the results of a questionnaire that examined previous athletic experience and preferred modality of exercise.

Experimental Tests:

Cycle Ergometer VO₂max test
Treadmill VO₂max test

Experimental Design:

The participants reported to the lab on a total of three occasions. The first time was for a familiarization trial which allowed them to become familiar with the testing equipment and maximal test procedures. Participants returned on two separate occasions to perform maximal testing. Each participant performed one test on the cycle ergometer and one on the treadmill. The order of the testing was randomized for each participant. Participants were instructed to refrain from strenuous exercise 24 hours prior to testing and eat a light carbohydrate meal at least 3 hours prior to testing. Following the completion of all testing, mean scores from each group of VO₂max tests were compared using a 2x3 (time x group) repeated measures ANOVA. Differences between predicted and actual means within individual groups and modalities were compared using paired t-tests.

Table 1. Study Design. Participants performed this sequence one time over the course of four weeks

Familiarization Trial	First Test	10 Day Break	Second Test
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Procedure:

Cycle:

- Start at resistance of 50 Watts at a speed of 80-100 RPMS for two minutes
- Test starts at 100 Watts at a speed of 80-100 RPMS
- Resistance increases every two minutes by 25 Watts
- Once participant reaches fatigue, HR within 5 BPM of max, or RER exceeds 1.1 the test is terminated
- A five minute cool down period at a resistance of 50 Watts at a comfortable speed

Treadmill:

- Start at a comfortable jogging speed for two minutes
- Test starts and speed increases by 1 MPH every two minutes
- Once max speed is reached, grade increased by 1% every two minutes
- Once participant reaches fatigue, HR within 5 BPM of max, or RER exceeds 1.1 the test is terminated
- A five minute cool down period at a walking speed

Results

Table 2: Actual VO₂max means vs. Predicted VO₂max means by modality

	† Predicted Treadmill	Actual Treadmill	† Predicted Cycle Ergometer	Actual Cycle Ergometer
Runners	52.39*	45.34	41.06	41.20
Cyclists	43.49	39.92	36.68	35.28
Swimmers	50.50	46.82	42.28	40.28
Total Participant Means	48.80*	44.03	40.00	38.92

† Predicted values calculated using ACSM's VO₂max prediction equations from ACSM's Guidelines for Exercise Testing and Prescription (9th Edition)

* p < .05

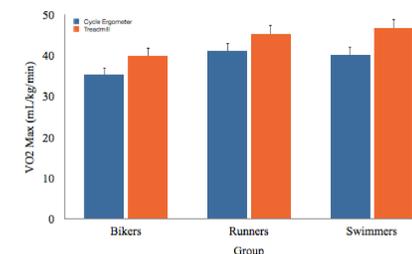


Figure 1. Actual VO₂max means between modalities within groups

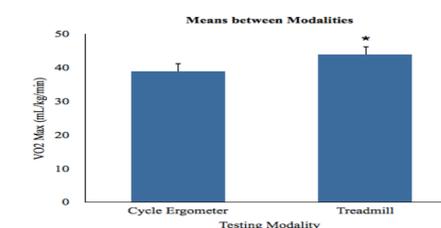


Figure 2. Actual VO₂max means between modalities
* p-value = 0.019

Conclusions

- There is a significant difference between the two testing modalities (Fig. 2) but not between the three testing groups. This suggests that treadmill testing elicits a more accurate VO₂max due to the fact that it is a full body, weight bearing exercise.
- Swimmers had a significantly different VO₂max response on the treadmill than on the cycle ergometer. This supports our hypothesis, suggesting that swimmers will produce more accurate test data on the treadmill (Table 2).
- There was a significant difference between the values produced by the prediction equations and the recorded results for treadmill testing, but not on the cycle ergometer.
- It can be concluded that the prediction equation for the cycle ergometer is more accurate than the equation for the treadmill. Therefore, using the treadmill prediction equation to estimate a participant's running VO₂max may not be reliable enough to be used alone.
- There is a significant difference between the VO₂max values yielded from the cycle ergometer and the treadmill testing (Fig. 2). We can conclude that the treadmill test provides a more accurate representation of a participant's VO₂max regardless of their athletic history.
- In conclusion, based on our results and analysis we can accept our original hypothesis and conclude that swimmers produced a greater VO₂max when using the treadmill test.

Limitations

- Little background on comparing modalities of testing VO₂max
- Measurement error
- Equipment failure
- Scheduling 2 participants back to back days instead of typical 10 day protocol
- Convenience sampling of active, but untrained subjects; trained athletes would have been preferred

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