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Comparison of a Ramp Cycle Ergometer and a Staged Assault Fitness AssaultBike Protocol for the Assessment of VO_{2max}

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ABSTRACT

International Journal of Exercise Science 16(4): 613-619, 2023. We propose a new VO2max test using a progressive staged protocol on an Assault Fitness AssaultBike. Twelve healthy males performed a traditional ramp cycle ergometer test (TRAD) and a progressively staged AssaultBike protocol (AB) in a counterbalanced order. AB elicited higher immediate post-exercise lactate, absolute and relative VO2max, and maximum heart rate than TRAD (P = 0.006, P = 0.014, P = 0.007, and P = 0.001, respectively). The protocol outlined herein may provide a more accurate assessment of VO2max due to greater skeletal muscle mass recruitment that is more representative of the whole body.

KEY WORDS: VO2max, cardiorespiratory fitness, AssaultBike, graded exercise test

INTRODUCTION

Improved cardiorespiratory health correlates with increased maximal oxygen uptake (VO_{2max}); thus, the VO_{2max} test is a viable indicator of overall health and a measure of one's likelihood of cardiovascular-related mortality (5). Traditional assessment of an individual's VO_{2max} has been assessed using a treadmill or stationary cycle ergometer using a progressive staged or a linear ramp protocol in which a participant will continue exercising until they reach volitional exhaustion.

Lower-body dominant testing can elicit a premature termination due to local muscle fatigue in non-modality-trained subjects (6), potentially resulting in improper determination of an individual's whole-body $VO_{2max,}$ which may result in an inaccurate cardiovascular health classification. VO_{2max} is potentially task-dependent, and the traditional modalities used may not produce true maximal values primarily due to the lack of recruitment of the entire body's muscle mass. Understanding how different modalities elicit maximal values can be of significant

interest in research and clinical settings. Additionally, the use of treadmill can be logistically problematic, requiring more study staff and at high speeds can be less safe.
The Assault Fitness AssaultBike is an air-braked cycle ergometer that requires a user to utilize both arms and legs to produce work and is engineered such that power output increases exponentially with progressive increases in the fan's revolution rate. The use of air-braked cycle ergometers is currently limited in research literature with a small number of studies being reported (7, 8, 12-14). This study aimed to compare the cardiorespiratory responses of a progressive staged protocol on an Assault Fitness AssaultBike vs. a traditional electrically braked cycle ergometer using only the lower limbs. We hypothesized the AssaultBike protocol would elicit a higher VO_{2max} compared to the traditional test due to increased muscle mass contribution and greater overall work performed (1).

METHODS

Ethical Approval: The study was approved by the University of Georgia's Institutional Review Board (study no. 3355), with written informed consent obtained prior to any experimental procedures. The study conformed to the standards set by the *Declaration of Helsinki*, except for registration in a database. This study additionally conformed to the standards set by the Editorial Board of the International Journal of Exercise Science (11).

Protocol
Potential participants were recruited via word-of-mouth and flyers from the University of Georgia community. They completed a questionnaire to initially screen participants based on the following criteria. Inclusion criteria included healthy, non-smoking, active (cardiovascular exercise ≥ 150 min·week^{-1} and resistance exercise ≥ 2 h·week^{-1}) individuals. Participants were free of any history of cardiovascular, metabolic, musculoskeletal disease or illness requiring the ingestion of medications that affect metabolism or vascular function. Exclusion criteria included weight loss or gain exceeding 5% in the past 3 mo, any disease or medication known to alter metabolic, skeletal muscle, or vascular function, or tobacco use. If a potential participant reported supplement use, they were instructed to follow a 2-wk washout phase before testing.

Participants completed two assigned testing sessions in a counterbalanced order: a traditional cycle ergometer VO_{2max} test (TRAD) and a progressively staged AssaultBike VO_{2max} test (AB). At least 72 h separated trials. Participants refrained from exercise for 48 h before and caffeine and alcohol ingestion for 24 h before each trial. Participants were given pre-trial dietary recommendations consisting of a meal the 3 h before each trial consisting of 20% predicted resting energy expenditure (50% carbohydrate, 30% fat, and 20% protein) (10). Participants were given guidance on food selection to meet the prescribed energy content and macronutrient composition for this meal. Participants were instructed to consume similar foods each day during the study period, with food choices like their normal dietary habits. Upon arrival at the lab, participants were asked to confirm that they adhered to pre-trial dietary instructions.

For each trial, pulmonary gas exchange (Parvo Medics TrueOne 2400, Parvo Medics, Salt Lake City, UT, USA) and heart rate (Polar Electro Inc., Lake Success, NY, USA) data were collected throughout both trials and reduced to 10 s averages. Before and immediately after the cessation of exercise, blood lactate was measured (Lactate Plus, Nova Biomedical, Waltham, MA, USA). At the cessation of exercise, subjects were asked to report their rating of perceived exertion (RPE) (3). VO_{2max} was confirmed by satisfying four of the following requirements, (i) an RER ≥ 1.10, (ii) a plateau in oxygen consumption (change < 100 mL·min^{-1} in the last 30 s stage), (iii) a maximum heart rate ≥ 85% of the age-predicted maximal heart rate, (iv) RPE ≥ 18, and (v) blood lactate ≥ 7 mmol (15).

Traditional VO_{2max} Test (TRAD) was conducted using an electromagnetically braked cycle ergometer (Lode Excalibur Sport, Groningen, the Netherlands). The ergometer was adjusted to each participants' comfort. To determine $VO_{2max,}$ subjects completed a 3-min warmup at 50 watts (W), followed by a progressive 20 W·min^{-1} increase in resistance until participants' cadence fell below 60 revolutions per minute (RPM) despite strong verbal encouragement and volitional exhaustion ensued. Pulmonary gases were collected for 2-min prior to and 10-min following cessation of the test.

Assault Bike VO_{2max} Test (AB) was conducted using an AssaultBike Classic (Assault Fitness, Carlsbad, CA, USA). Participants performed a prescribed warm-up dependent on RPM, then rested for 3-min before beginning the protocol described in Table 1. The prescribed warm-up was chosen to allow participants to practice within the required RPM per stage. If the subject could not maintain the desired RPM, the entire warm-up was repeated to allow additional practice before the test. No participants required extra practice time. The test was concluded when participants could no longer cycle above the minimum RPM value in each stage or at the end of stage 9, when participants were instructed to cycle as fast as possible for 2-min. Participants were required to maintain the RPM range for the entire duration of the stage. If a participant deviated from the stage RPM range, either lower or higher, the test was concluded. No tests were concluded due to a participant exercising at higher RPM range. Pulmonary gases were collected for 2-min prior to and 10-min following cessation of the test.

Statistical Analysis

Student *t*-tests were conducted to assess the statistical significance of differences in peak power output, cardiorespiratory, and metabolic variables between TRAD and AB tests. Total exercise time was calculated by total time of test minus warm-up, rest, and post-exercise periods. Cohen's *d* was calculated to assess effect size where $d = 0.2$ represented a small effect, $d = 0.5$ represented a medium effect, and $d = 0.8$ represented a large effect (4). Assumptions of normality were verified for all outcome measures. Statistical significance was accepted at $P \leq 0.05$. Data are presented as means (SD) unless otherwise noted. All statistical analyses were performed with SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA).

Table 1. Progressive staged Assault Fitness AssaultBike VO_{2max} test protocol.

Stage	Time (min)	RPM	Watts
Warm-up	0:00-0:59	44	127
	1:00-1:59	48	159
	2:00-2:59	52	197
Rest	3:00-5:59	0	0
Stage 1	6:00-8:59	42-44	113-127
Stage 2	9:00-11:59	47-49	151-168
Stage 3	12:00-14:59	50-52	176-197
Stage 4	15:00-17:59	53-55	207-228
Stage 5	18:00-19:59	56-58	240-265
Stage 6	20:00-21:59	60-62	288-316
Stage 7	22:00-22:59	64-66	345-376
Stage 8	23:00-23:59	67+	>392
Stage 9	24:00-25:59	All-out effort	

Note: RPM, revolutions per minute.

RESULTS

Twelve healthy, non-smoking, active males were recruited (22.42 (3.34) y, 86.18 (10.84) kg, and 26.63 (3.51) kg·m^2). All participants reached four out of five criteria for VO_{2max}. AB elicited significantly higher immediate post-exercise lactate and RPE, absolute and relative VO_{2max}, maximum heart rate, peak power, and total exercising time compared to TRAD ($P < 0.05$, Table 2). Additionally, participants' maximal aerobic power was recorded in the 50th percentile for AB and the 40th percentile for TRAD (9). A post-hoc power analysis revealed a power of 0.813 for relative VO_{2max}, suggesting the current study had sufficient power.

Table 2. Differences and associations of peak power, cardiorespiratory, and metabolic variables between TRAD and AB tests.

	TRAD Test	AB Test	*T*-test	Cohen's *d*
Baseline Lactate (mmol·L^1)	1.01 (0.29)	0.98 (0.36)	$P = 0.847$	0.06 (-0.62, 0.51)
IP Lactate (mmol·L^1)	10.73 (1.86)	12.76 (2.41)	$P = 0.006$	0.98 (0.27, 1.67)
IP RPE	16.92 (2.07)	18.00 (1.65)	$P = 0.035$	0.69 (0.05, 1.31)
VO_{2max} (l·min^1)	3.84 (0.50)	4.10 (0.45)	$P = 0.014$	0.85 (0.17, 1.50)
VO_{2max} (ml·kg^1·min^1)	44.72 (5.30)	47.89 (5.00)	$P = 0.007$	0.95 (0.25, 1.63)
VCO_{2max} (l·min^1)	4.38 (0.54)	4.52 (0.67)	$P = 0.176$	0.42 (-0.18, 1.00)
VE_{max} (l·min^1)	117.97 (16.59)	123.29 (17.05)	$P = 0.078$	0.56 (-0.06, 1.16)
Maximum RER	1.18 (0.57)	1.21 (0.09)	$P = 0.306$	0.31 (-0.208, 0.88)
Maximum Heart Rate (beats·min^1)	180.80 (10.33)	189.07 (7.29)	$P = 0.001$	1.28 (0.49, 2.03)
Peak Power (W)	311.25 (35.92)	426.42 (102.96)	$P < 0.001$	1.38 (0.56, 2.16)
Total Exercising Time (min)	12.82 (1.83)	18.69 (1.77)	$P < 0.001$	4.95 (2.83, 7.06)

Note: TRAD, traditional cycle ergometer VO_{2max} test; AB, progressively staged AssaultBike VO_{2max} test; CI, confidence interval; IP, immediate post-exercise; RPE, rating of perceived exertion using Borg scale; RER, respiratory exchange ratio; mmol, millimole; l, liter; ml, milliliter; kg, kilogram; min, minute; W, watts.

DISCUSSION

This study aimed to evaluate the cardiorespiratory response of a progressive staged protocol on an Assault Fitness AssaultBike in relation to a traditional ramp protocol on a cycle ergometer. The main findings of the study include elevated but similar cardiorespiratory response during the AB as compared to TRAD.

These results support using a progressive staged protocol on an Assault Fitness AssaultBike to assess individuals' VO_{2max}. The protocol and equipment used herein may provide a more accurate assessment of VO_{2max} due to the ability to recruit a greater amount of skeletal muscle mass that is more representative of the whole body. A treadmill protocol elicits a higher VO_{2max} compared to a cycle ergometer (2), presumably from the recruitment of the entire leg musculature and arm movement (i.e., increased skeletal muscle mass recruitment). The increased availability of the upper body to contribute to work allows for an increased work rate, ultimately resulting in higher cardiorespiratory classification, thus eliciting a greater cardiovascular response and increased oxygen uptake to match the demand of both the upper and lower body skeletal muscles involved.

In some settings, a cycle ergometer may be preferred over a treadmill due to the decreased risk of injury. One disadvantage of using a cycle ergometer is the potential for premature test conclusion in non-trained participants due to local lower body muscle fatigue rather than cardiorespiratory fatigue. Using an Assault Fitness AssaultBike may allow better quantification of participants' cardiorespiratory capacity by incorporating greater skeletal muscle mass recruitment while providing a risk-averse modality. Future studies should compare the current AssaultBike protocol to a treadmill VO_2max protocol.

The current study only included young, healthy males with a relatively small sample size. Future investigations should examine possible interactions among sex, age, and clinical populations. Larger sample sizes are warranted for confirmation of our current data. Furthermore, our AB protocol may need to be modified for specific applications, e.g., for individuals with lower fitness levels. The current AB protocol should be modified to reduce total exercising time of the test to resemble current VO_{2max} testing time recommendations. We believe future investigators should remove Stage 1. Analysis of skeletal muscle mass would explain how skeletal muscle mass influences cardiorespiratory response from a whole-body VO_{2max} test. Lastly, individual exercise modality preferences may influence findings when comparing protocols and modalities to elicit a VO_{2max}. Future research should address these concerns.

Conclusion: The current study showed elevated but similar cardiorespiratory response during the AssaultBike test compared to a ramp cycle ergometer test. The proposed staged Assault Fitness AssaultBike protocol represents a viable approach to assessing an individual's maximal oxygen uptake. Future investigations should examine possible interactions among sex, age, and clinical populations with larger sample sizes.

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DISCLOSURE STATEMENT

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AUTHOR CONTRIBUTIONS

Experiments were conducted in the Integrative Cardiovascular Physiology Laboratory located in the Department of Kinesiology at the University of Georgia. RCP and NTJ conceived and designed the research. RCP and SG collected data. RCP and NTJ analyzed the data. All authors contributed to the interpretation of the results. RCP and NTJ drafted the manuscript. All authors edited and revised the manuscript. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring the questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All persons designated as authors qualify for authorship, and all those who qualify for authorship are listed.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current work are not publicly available but are available from the corresponding author on reasonable request.

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