HONG KONG SPORTS INSTITUTE
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RESEARCH HIGHLIGHTS

A Hybrid Aerobic Test : the Incremental + MVO_2 test

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Introduction

Anaerobic threshold (AT) and maximum oxygen uptake (MVO_2) are two key performance indicators for many endurance events, such as rowing and marathon running. The commonly accepted ventilatory threshold (VT) method for determining the AT in the traditional maximum uptake ($TMVO_2$) test has proven that there is not a strong correlation between VT and AT [1]. Therefore, we aimed to investigate this correlation and establish a single reliable test for both MVO_2 and AT. We thus proposed to implement a lactate threshold (LT) protocol into the early phase of the $TMVO_2$ test, thereby developing a hybrid of the LT test and $TMVO_2$ test (Incremental + MVO_2 test). We hypothesised that this Incremental + MVO_2 test would: (1) obtain the same MVO_2 value as the $TMVO_2$ test; and (2) be a more comprehensive protocol, enabling the determination of more lactate values related to AT than the $TMVO_2$ test. This would assist the understanding of one's lactate clearance ability, leading to the development of improved individualised training programmes based on more accurate measurement of an athlete's physiological state.

Methodology

Subjects: Thirteen female collegiate rowers (age 19.92 ± 1.14 years, height 166.61 ± 4.04 cm, body mass 58.17 ± 3.48 kg) participated in the study. They had previously engaged in rowing training for > six months, at an average training frequency of five days per week.

Study design: All subjects completed a $TMVO_2$ test and an Incremental + MVO_2 test on a rowing ergometer (Model D Ergometer; Concept II, Inc, Morrisville, VT, USA), with these two tests being performed seven days apart, and the order of these two tests being randomly assigned. Subjects' power exertion, heart rate, respiratory gases, lactate samples and rate of perceived exertion were collected throughout the test, according to protocols.

$TMVO_2$ test: This began at 100 W for three minutes, then increased 15 W every minute until exhaustion. Each test took between 10 and 13 minutes to complete. The VT method was used for the AT determination. We evaluated the VT in a combined model that comprised three methods, i.e. [2]:

1. Excess CO_2 method ($ExCO_2$ method): The exercise intensity that leads to an increase in $ExCO_2$ from steady state. The $ExCO_2$ was calculated as $((VCO_2^2/VO_2) - VCO_2)$;
2. Ventilatory equivalents method (VEQ method): The exercise intensity that results in the first rise in the ventilatory equivalent of O_2 (VE/VO_2) without a concurrent rise in the ventilatory equivalent of CO_2 (VE/VCO_2);
3. V-slope method (V-slope): The exercise intensity that results in an increase in the slope from < 1 to > 1 in a plot of the minute production of (VCO_2) over the minute utilisation of O_2 (VO_2).

The deflection points were independently detected by two experienced investigators.

Incremental + MVO_2 test: this consisted of two parts:

A) AT determination

This began at 100 W for three minutes, with subsequent increases of 15 W for each three-minute . Each incremental step was separated by a 30 s break for sampling earlobe-blood lactate. AT determination ended when the lactate value exceeded 4 mmol/L and when the increment was ≥ 1.1 mmol/L between incremental steps. AT determination was made using the LT method, in which the transition was determined as the incremental step prior to a ≥ 1.1 mmol/L lactate increment. A four-minute rest was taken before the next test.

B) MVO_2 determination

The power at LT was set as the initial level for one minute, then increased 15 W every minute until exhaustion. The test time for both Incremental and MVO_2 was approximately 30 minutes.

Results and Discussion

In the maximal stage, both the Incremental + MVO_2 test and the $TMVO_2$ test gave MVO_2 values (Table 1), and there were no differences in the power, VO_2 and heart rate results between these two tests ($p > 0.05$). Hence, it was concluded that both tests are applicable to estimate MVO_2 and the corresponding heart rate and power for rowers.

In the AT stage, there was no difference between the heart rate in the Incremental + MVO_2 test and $TMVO_2$ test ($p > 0.05$) (Table 2). However, the power and the VO_2 values were different between the two tests ($p < 0.05$), being greater in Incremental + MVO_2.

Table 1. Maximum oxygen uptake (MVO_2) determination stage in $TMVO_2$ test and incremental + MVO_2 test (values are Mean ± Standard Deviation)

	$TMVO_2$ test	Incremental + MVO_2 test
Maximum Power (W)	200.1 ± 19.58	197.4 ± 23.1
MVO_2 (ml/kg/min)	46.5 ± 1.73	45.8 ± 2.44
Maximum heart rate (bpm)	187.7 ± 5.85	189.9 ± 5.06

Table 2. Anaerobic threshold (AT) determination stage in $TMVO_2$ test and Incremental + MVO_2 test (values are Mean ± Standard Deviation)

	$TMVO_2$ test†	Incremental + MVO_2 test^
Power (W)	130 ± 41.29	133.5 ± 16.34*
VO_2 (ml/kg/min)	38.1 ± 2.94	39.9 ± 3.21*
Maximum Heart rate (bpm)	166.15 ± 7.82	162.15 ± 7.37

† VT method was used
^ LT method was used
* Significant difference ($p < 0.05$)

The findings indicated that the Incremental + MVO_2 test is a reliable MVO_2 test for rowers. In addition, when considering the protocols and underlying principles, the Incremental + MVO_2 test may have several decisive advantages over the $TMVO_2$ test in AT determination.

For example, the three-minute incremental steps in the AT determination phase allowed stabilisation of VO_2, with this duration required to reach a relatively stable VO_2 level at low intensity (≤ AT intensity) [3]. Thus, the VO_2 value at AT based on the VT method from the $TMVO_2$ test (one-minute duration at each intensity) might be underestimated (Table 2).

Furthermore, the Incremental + MVO_2 test offered a doubly authenticated mechanism to identify a more accurate determination of the AT deflection point. The first part of an Incremental + MVO_2 test has a series of 30-second breaks between each incremental step, and this allows the investigator to monitor and also determine the aerobic-anaerobic transition turning-point by taking both LT and VT into account. Notably, the 30-second breaks had a negligible effect on the lactate profile [4] when compared with the continuous Incremental protocol.

As the Incremental + MVO_2 test was conducted on female collegiate rowers, it must also be used to assess male collegiate rowers before the results of our novel hybrid aerobic test can be generalised to other populations.

Conclusion

The MVO_2 obtained in our Incremental + MVO_2 test of female collegiate rowers was identical to that obtained from a $TMVO_2$ test of the same group, and also afforded a more comprehensive and accurate assessment of AT compared with the $TMVO_2$ test. This will lead to improvements in the understanding of lactate clearance ability, facilitating the development of superior individualised programmes based on more accurate measurements of the physiological state of female collegiate rowers.

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