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Can the Running-Based Anaerobic Sprint Test be used to Predict Anaerobic Capacity?

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ABSTRACT

Kaminagakura EI, Zagatto AM, Redkva PE, Gomes EB, Loures JP, Kalva-Filho CA, Franco VH, Papoti M. Can Running-Based Anaerobic Sprint Test be used to Predict Anaerobic Capacity? **JEPonline** 2012;15(2):90-99. The purpose of this study was to determine if the use of the running-based anaerobic sprint test (RAST) could be used to predict anaerobic capacity in running athletes. Eleven male middle-distance runners (21 ± 1 yrs) volunteered to take part in this study. The maximum accumulated oxygen deficit (MAOD) was determined during running on a treadmill, and the RAST was determined during running on a track. None of the variables associated with RAST output (peak power, mean power, fatigue index, and maximal and mean velocities) was significantly correlated with MAOD. Thus, the findings indicate that the use of the RAST does not predict anaerobic capacity in running.

Key Words: Anaerobic Capacity, Running, RAST, MAOD

INTRODUCTION

Anaerobic capacity is defined as the maximum amount of adenosine triphosphate that can be resynthesized via anaerobic metabolism (both alactic and lactic systems) during maximal exercise (10,22). Currently, the maximum accumulated oxygen deficit (MAOD) is considered the gold standard to estimate anaerobic capacity (15). In addition to being sensitive to anaerobic training (28,29), MAOD is correlated with performance in high intensity efforts (32) and it is used to validate other methods that evaluate anaerobic conditioning (3,7,23,38).

To use MAOD to estimate anaerobic capacity is not easy. It requires several submaximal exercise bouts and one supramaximal exercise bout (19). It is also difficult to use MAOD during the periodized training routine. Furthermore, it is necessary to measure the oxygen uptake (VO_2) during the exercise bouts, which makes the methodological use of MAOD a high financial cost. As a result of these factors, it is important to identify easier application at a lower cost. This would enable the widespread use of the procedures in the evaluation and monitoring of sports training.

For example, the Wingate test (WanT) (2,26), jump tests (15), attained running (39), and the maximal anaerobic running test (MART)(26) are inexpensive and commonly used. These methodologies have been studied for a considerable period of time, and they have been applied in the evaluation of anaerobic power of athletes (18,25,38), healthy subjects (13,35), and cardiac patients (21).

Several studies have demonstrated a relationship between the parameters measured from WanT and anaerobic capacity (22,37). Scott et al. (32) found significant correlations between peak power (PP) from WanT and MAOD determined on a treadmill. Minahan et al. (22) showed that the mean power (MP) and fatigue index (FI) from WanT were correlated with MAOD. Green et al. (1993) reported that the mean power, peak lactate and/or fatigue index can estimate the activity of the glycolytic system and represent rate of anaerobic capacity. Despite the use of these parameters to estimate anaerobic capacity, there is still disagreement as their true value (22).

Moreover, although the WanT is a rapid (30 sec) test that is easy to apply and at relatively low cost, it is usually performed on a cycle ergometer and therefore is not appropriate for running sports (16). On the other hand, the running-based anaerobic sprint test (RAST), which is adaptation of the WAnT to running (40), has been widely used to assess anaerobic fitness. The RAST output (i.e., peak, power, mean power, fatigue index, maximal speed, and mean speed) are similar to those determined in WAnT, showing high correlations with the same variables (40). Zagatto et al. (37) showed that the RAST is a reproducible and valid procedure for assessing anaerobic power. It is acknowledged as a good predictor of running performance (35 to 400 m), which can be easily added to be training routine. Additionally, this methodology is used to evaluate athletes in many sports such as soccer (1), basketball (4), and handball (30).

However, despite the easy, specificity, and low costs involved in applying the RAST, additional analysis is needed. The purpose of this study was to determine if the use of the running anaerobic sprint test (RAST) could be used to predict anaerobic capacity in running athletes.

METHODS

Subjects

The sample size was calculated based on the assumption that MAOD hold significant and strong correlation coefficients higher than 0.80 with other anaerobic parameters (3). G*Power 3.1 software (Düsseldorf, Germany) was used to determine that a sample size of nine subjects was the minimum needed to provide a statistical power of 90% with an alpha of 0.05 for statistical significance. Eleven runners volunteered (21 ± 0.7 yrs, 66.3 ± 1.2 kg of body weight and 171.0 ± 1.0 cm in height) from the Brazilian army. The subjects were middle distance runners with a background in 800 m to 5000 m. They trained five weekly sessions lasting 120 min at an average volume of 60 km · $week^{-1.}$ All subjects were informed of the risks and benefits and gave written consent regarding the experimental procedures. All procedures were conducted according to the declaration of Helsinki.

Procedures

The experimental procedures were applied during a 7-d period, separated by a minimal interval of 24 hrs. During the tests, the subjects were released from military activities, including training, and were instructed not to perform strenuous exercise prior assessments. They were also asked not to consume alcohol, caffeine, and tobacco during the period of participation in the study.

During the 1st day, the subjects underwent a graded exercise test (GXT) to determine maximal oxygen consumption (VO_2 max) and the intensity associated at VO_2 max (iVO_2 max). During the 2nd to the 6th-day, the subjects underwent four submaximal efforts (50, 60, 70, and 80% of iVO_2 max). The efforts were performed randomly followed by a supra-maximal effort (120% of iVO_2 max) for determination of MAOD. On the 7th day, the subjects engaged in the RAST on an official running track. The GXT, submaximal, and maximal exercises were used to determine MAOD; all were performed on a motorized treadmill (ATL Inbramed, Inbrasport, Porto Alegre, Brazil) with the slope fixed at 1% (16). Five minutes of moderate intensity exercise was used as warm-up, with the test beginning after 5 min of passive recovery.

During each of the laboratory tests, GXT, submaximal, and maximal exercises, VO_2 was measured breath-by-breath using a True-One 2400 gas analyzer (ParvoMedics, EastSandy, Utah, USA). The gas analyzers were calibrated immediately before and verified after each test using a certified gravimetrically determined gas mixture, while the ventilometer was calibrated pre-exercise and verified post-exercise using a three liter syringe in accordance with the manufacturer's instructions. Following removal of outliers to exclude discrepant breaths, breath-by-breath VO_2 data were interpolated to give 1-sec values and, then, smoothed using rolling 30-sec averages (OriginPro 8.0, OriginLab Corporation, Microcal, Massachusetts, USA) to enhance the underlying VO_2 response characteristics. In every test, the start and the end-time of each run (i.e., exercise stage) was recorded for later synchronization between ventilatory data and running events

GXT to Determine VO_2 max and Intensity Associated to VO_2 max (iVO_2 max)

The maximal oxygen uptake (VO_2 max) and velocity associated with VO_2 max (iVO_2 max) were estimated in a maximal GXT beginning at 12 km · h^{-1} and increased by 1 km · h^{-1} every 3 min until voluntary exhaustion. The treadmill grade was fixed at 1%. Maximum oxygen consumption was considered as the highest VO_2 average achieved during the last 30 secs of each stage, when at least two of the three following criteria were obtained: (a) blood lactate concentration greater than 8 mM; (b) heart rate greater than 90% of maximum predicted age (220 – age); and (c) a respiratory exchange ratio of 1.1 or greater. The velocity associated with VO_2 max (iVO_2 max) was considered the lowest velocity at which VO_2 max was achieved.

Determination of the Maximum Accumulated Oxygen Deficit (MAOD)

The subjects performed four 7-min submaximal running bouts corresponding to 50, 60, 70, and 80% iVO_2 max. Oxygen consumption was measured throughout each 7-min exercise period as previously described, and VO_2 during the last 1-min of each bout was averaged and used as the steady-state VO_2 for the corresponding velocity. After the submaximal intensity exercise sessions (i.e., 5 min of passive recovery), a 120% iVO_2 max supramaximal exercise was performed to measure time to exhaustion and VO_2.

A linear regression line was fitted through a fixed y-intercept 5.1 mL · kg^{-1} · min^{-1} (for more details see Medbo et al., 19), and four submaximal intensities and their respective steady-state VO_2 values. This regression line was extrapolated and the oxygen demand corresponding to 120% iVO_2 max was estimated. Therefore, MAOD was calculated as the difference between estimated VO_2 demand area (estimated VO_2 demand multiplied by time to exhaustion) and VO_2 integrated over time in the maximal exercise.

Running Anaerobic Sprint Test (RAST)

Total body mass of the subjects was determined using a digital scale (Tanita UM080, Brazil), including clothing used during testing. The running anaerobic sprint test (RAST) consisted of six 35 m maximal runs separated by a period of 10 secs of passive recovery. The record time was conducted every effort by a photocell system (CEFISE, Brazil) located at the beginning and at the end of the route. Power (Pabs) was determined for each run by measuring the time (t), distance (D), and total body mass (TBM) of the subject (Pabs (W) = $(TMCxD^2) / t^3$).

The running anaerobic sprint test (RAST) variables were peak power (PP), mean (MP) both presented in units relative to body mass (rel) and absolute (abs) values, and also the fatigue index (FI) (FI (%) = (PP – minimal power) x 100) / PP). Furthermore, given the relationship between distance and time, effort was determined as maximum velocity (Vmax) and mean velocity (Vmean).

Statistical Analyses

The normality and homogeneity of the variables were tested and confirmed by the Shapiro-Wilk and Levene tests, respectively. The correlations between parameters from the RAST and MAOD were analyzed by means of the product-moment correlation test using a significance level of 5% ($P<0.05$) (Statistical Package STATISTICA 7, Statsoft, USA). For the analysis of correlation coefficients (r), in addition to the significance level ($P<0.05$), the correlation coefficients were classified the very weak to negligible (0.0 to 0.2), weak (0.2 to 0.4), moderate (0.4 to 0.7), strong (0.7 to 0.9), and very strong (0.9 to 1.0) (30).

RESULTS

Maximum oxygen consumption (VO_2 max) and iVO_2 max measured during the GXT corresponded to 57.5 ± 4.3 mL · kg^{-1} · min^{-1} and 15.9 ± 1.0 km · h^{-1}, respectively. The coefficient of regression (R^2) obtained from the linear VO_2-intensity regression using submaximal values was 0.95 ± 0.04 (range 0.86 to 1.0), and the time to exhaustion at 120% of iVO_2 max was 200.5 ± 44.3 secs. Thus, it was possible to determine the MAOD value that is shown in the Table 1. The RAST values also are shown in the Table 1. No significant correlations were found among the MAOD value and RAST parameters. The correlation coefficients are presented in the Table 2.

Table 2. Values (Mean ± SD and Range) of MAOD and RAST Parameters.

	MEAN	SD	Maximal	Minimal
MAOD (L)	3.6	1.5	6.5	1.7
MAOD ($mL \cdot kg^{-1}$)	54.4	22.4	98.4	26.1
PP (W)	598.6	119.4	825.2	438.1
$\mathbf{PP_{rel}}$ ($mL \cdot kg^{-1}$)	9.0	1.7	12.5	7.0
MP (W)	451.3	119.2	701.5	319.2
$\mathbf{MP_{rel}}$ ($mL \cdot kg^{-1}$)	6.8	1.8	10.6	5.0
FI (%)	40.5	9.4	55.6	26.7
Vmax ($m \cdot s^{-1}$)	6.8	0.4	7.6	6.3
Vm ($m \cdot s^{-1}$)	6.1	0.5	7.2	5.6

MAOD = maximal accumulated oxygen deficit; PP_{rel} = peak Power relative to body mass; MP_{rel} = Mean Power relative to body mass; PP = peak power; MP = Mean power; FI= fatigue index; Vmax = Maximal velocity; Vmean = mean velocity.

Table 2. Correlation Coefficients between the MAOD Values and RAST Parameters.

	MAOD (L)		**MAOD** ($mL \cdot kg^{-1}$)	
	r	P	r	P
PP (W)	0.45	0.13	0.42	0.15
PP ($W \cdot kg^{-1}$)	0.41	0.16	0.41	0.17
MP (W)	0.29	0.34	0.26	0.39
MP ($W \cdot kg^{-1}$)	0.26	0.39	0.25	0.40
FI (%)	0.15	0.64	0.14	0.66
Vmax ($m \cdot s^{-1}$)	0.41	0.16	0.41	0.17
Vmean ($m \cdot s^{-1}$)	0.23	0.46	0.22	0.47

PP_{rel} = peak Power relative to body mass; MP_{rel} = Mean Power relative to body mass; PP = peak power; MP = Mean power; FI = fatigue index; Vmax = Maximal velocity; Vmean = mean velocity.

DISCUSSION

The main findings of this study were the weak and non-significant correlations between the RAST and MAOD, including the mean power and fatigue index, which are associated with indices of anaerobic capacity (9,22).

The results of this study indicate that RAST cannot be used to predict anaerobic capacity, which is in contrast to that observed in cycle ergometer (4). Moreover, Minahan et al. (22) reported using the cycle ergometer when WAnT showed that the MP had significant correlations with MAOD (i.e., when these parameters were shown in absolute values, r = 0.65). Furthermore, the FI demonstrated correlations with MAOD both in absolute (r = -0.60) and lean mass on the active (r = -0.71). Yet, Minahan et al. (22) suggest that power does not indicate capacity and, if the WAnT is used to estimate the anaerobic capacity, the IF should be used rather than peak power and mean power.

However, the short 30-sec duration of WAnT (20), and the aerobic contribution involved during this test (27) are factors that are not normally taken into account (22). They should be considered when a test is suggested for the assessment of anaerobic capacity (31). In this sense, the same as in WAnt, two hypotheses can be proposed for the lack of correlation between the MP and FI from RAST and MAOD.

The first hypothesis is related to the loads in RAST. Medbo and colleagues (19) have shown that for maximum accumulated deficit O_2 can be achieved in the supra-maximum effort, but it must be done by at least 2 min. Therefore, the total duration of the effort during the RAST (~29 ± 1.75 secs, similar to WAnt) was probably insufficient for a significant depletion of the anaerobic supplies, which likely had an influence on the correlation between the variables from this methodology and MAOD.

The second hypothesis is related to the intermittent feature of the RAST. In agreement with the findings of the present study, Glaister and colleagues (11) determined the MP and FI from an intermittent high intensity protocol, using 20 bouts of 5-sec effort interspersed with 10-sec and 30-sec intervals. They did not find significant correlation for either MP or FI with MAOD, which indicates the ability to maintain performance that is different from that observed in maximum permissible short bouts (e.g., WAnT) is not associated with anaerobic capacity (22).

In this sense, aerobic contribution may be higher in the intermittent high-intensity efforts than in the continuous efforts of high intensity (e.g., WAnT), mainly by the fact that during periods of recovery VO_2 stays high for the removal of the intra-cellular metabolites such as like inorganic phosphate (Pi) and lactate. In addition, aerobic metabolism is ongoing during the recovery period for the resynthesis of phosphocreatine and O_2 supply to myoglobin, which is essential for maintaining the performance (12,33,34). Also, if maximum physical stress is repeated without full recovery of the cellular energy sources, (i.e., substrates), it may be difficult to maintain the performance (6). It appears therefore that the contribution of the aerobic RAST values of MP and FI may have been exacerbated by influencing the correlations of the values with the anaerobic capacity determined by MAOD. More research is required to better understand the interactions between the variables that relate to both aerobic and anaerobic metabolism and intermittent high-intensity performances.

A limitation of this study may have been the determination of MAOD using only four submaximal efforts. However, in support of the present protocol, the practical application of the submaximal efforts (10-20) proposed by Medbo et al. (19) is not possible during routine training. With this point in mind, Hill (14) suggested an alternative method for determining the MAOD. That method consists of using only four submaximal efforts, observing a significant correlation (r = 0.96) between that and the method proposed by Medbo and colleagues (19). Also, it is apparent that numerous studies have determined MAOD using five or less submaximal efforts (5,8,13,21,24,36). More studies are needed to determine the possible correlations between parameters from the RAST and anaerobic capacity, measured by the MAOD using more points for determining the demand for O_2 and submaximal intensities.

CONCLUSIONS

From the results of this study, it can be concluded that the RAST outputs (i.e., peak power, mean power, and fatigue index) cannot be used to estimate anaerobic capacity.

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