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Prediction of Aerobic Performance in Distance from 1200 to 2800 M for Laboratory Testing with Military Runners

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ABSTRACT

Redkva PE, Zagatto AM, Gomes EB, Kalva-Filho CA, Loures JP, Kaminagakura EI, Papoti M. Prediction of Aerobic Performance in Distance from 1200 to 2800 M for Laboratory Testing with Military Runners. **JEPonline** 2012;15(5):107-114. An analysis of different techniques for the prediction of running performance has been widely investigated to improve athletes. The purpose of this study was to evaluate the use of laboratory tests to predict running performance. The relationship between maximal oxygen consumption (VO_2 max), velocity associated with VO_2 max (vVO_2 max), and critical velocity (CV) with 1200, 2400, and 2800 m performances. Thirteen Brazilian Army runners performed an incremental treadmill test starting at 12 $km \cdot h^{-1}$ with increments of 1 $km \cdot h^{-1}$ every 3 min until exhaustion to determine VO_2 max and vVO_2 max. Later, the runners ran at 100, 110, and 120% of vVO_2 max to determine CV on treadmill. In addition to the laboratory test, the subjects performed three maximal runs at 1200 (P1200), 2400 (P2400), and 2800 (P2800) m on the track. Data normality was verified using the Shapiro Wilk's and Pearson correlations (P=0.05) were used to determine the relationship between the laboratory variables and the performances field test. The results showed significant correlations for P1200, P2400, and P2800 with CV (r = -0.70) and vVO_2 max (r = -0.85). Based on the results of this investigation, we conclude that CV and vVO_2 max determined in the laboratory can be used to predict performance in the distances studied in military runners.

Key Words: VO_2 Max, vVO_2 Peak, Critical Velocity, Field Performances

INTRODUCTION

The evaluation of specific physiological variables is commonly used to predict athletic performance and, therefore, the success of athletes in different sports (6). Currently, there are several protocols used to predict aerobic performance in athletes at all levels (9,26,31). Maximal aerobic power, estimated by determining maximal oxygen consumption (VO_2 max), is commonly regarded as the best indicator of endurance sports. As a result, VO_2 max is frequently used to monitor training and periodization (19,21).

Despite that VO_2 max is the conventional method of assessing endurance performance (19), the procedure is limited in the evaluation of trained athletes and the identification of the physiological adaptations that occur with periodized training (2). However, the minimal velocity at which VO_2 max is reached (vVO_2max) (22,28) is highly correlated with endurance performance (15). Another method in the determination of aerobic indices is the mathematical model of critical velocity (CV) (5). This methodology is based on the highest exercise intensity that can theoretically be maintained for a very long time without exhaustion (26). The great advantage of using CV to assess aerobic performance is the easy application and non-invasive technique required of using sophisticated equipment for CV determination (27).

Defining the aerobic physiological parameter through CV is possible from the application of loads that are predictive of exercise performed until voluntary exhaustion (usually, 2-10 minutes) (23). Based on these data (i.e., intensity and Tlim), the aerobic parameter is measured by means of mathematical models such as linear regressions of distance-time relation (16), intensity-inverse of time relation ($Tlim^{-1}$) (14), and the hyperbolic relation between intensity and Tlim (23).

Thus, in view of the various methods employed in the literature to evaluate the performance of runners, the purpose of this study was to investigate the use of laboratory test to predict the run performances performed on a track. Specifically, this study investigated the relationship between VO_2max, vVO_2max, and CV obtained in laboratory tests on a treadmill with the speeds of the performances in field trials with runners of the Brazilian Army.

METHODS

Subjects

The study included 12 well-trained military men (20.1±2, 1 yr, height 1.70±0.06 m, and weight of 66.0±3.7 kg). All subjects participated in military competitions at the national level. The subjects had a weekly training routine of 6 $d \cdot wk^{-1}$ with volume around 70-85 $km \cdot wk^{-1}$. The study was performed during the specific preparation of the periodization. All procedures were approved by the University´s Institutional Review Human Subjects (Human Research Ethics Committee), and were conducted in accordance with the Declaration of Helsinki. The subjects were kept informed about experimental procedures and risks; all signed an informed consent before participation in the study.

Procedures

During the period of testing, each subject was instructed to maintain the same standard food, abstain from alcohol intake, and avoid exercise during the test application. All procedures were carried out in 2 wks, performed only in the morning and in similar environmental conditions (temperature between 22-24° C). Before the implementation of each effort, all subjects performed 5 min of warming at a moderate intensity on a treadmill before starting the test followed by 5 min of passive recovery.

The subjects performed a maximal incremental test to determined VO_2max and $vV0_2$max. After performing the test, they performed 3 runs at intensities corresponding to 100, 110, and 120% of vVO_2max to determined CV. Between each procedure an interval of least 24 hrs was required. In all the laboratory procedures, the analysis of gases was measured breath-by-breath using a gas analyzer ParvoMedics (TrueOne Metabolic Measurement System®2400 – USA). The equipment was calibrated with known gas samples containing 3.98% CO2 and 16.02% O_2, while the ventilation flow was calibrated using a syringe with a volume of 3 L (Hans Hudolf, USA). In all tests, strong verbal encouragement was used to motivate the subjects to perform maximum efforts until volitional exhaustion, both in the laboratory and during the field performances to carry out the performance in the shortest time possible.

Determination of VO_2 Max and vVO_2 Max: Maximal oxygen uptake (VO_2 max) and velocity associated with VO_2 max (vVO_2max) (4,15) were obtained from the maximal incremental test with an initial velocity of 12 $km{\cdot}h^{-1}$ that was increased by 1 $km{\cdot}h^{-1}$ every 3 min. Treadmill grade was set at 1% (17). The VO_2 max was considered as the highest average during the last 30 sec of exercise with at least two of the criteria obtained: (a) HR =maximal age-predicted HR (220-age); (b) respiratory gas exchange ratio =1.10; and (c) plateau (variations =2.1 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ between last 2 exercise stages). If exhaustion occurred before the end of the exercise stage, VO_2max was determined in accordance with Kuipers et al. (18).

Determination of CV: To determine CV, athletes performed 3 maximal efforts on a treadmill at velocities corresponding to 100, 110, and 120% of vVO_2max. The time to exhaustion (Tlim) in each intensity was recorded by digital chronometer (Timex, TI5G811® Manaus, Brazil), and stored in individual spreadsheets. The runners started the race at the pre-identified speed, holding onto the sidebar of the treadmill to suit the relevant race past the velocity in question, and afterwards released the sidebars (~5 sec). Timers were activated to measure the Tlim characterized by the time the runner once again held onto the sidebars. In all cases, the order of the velocities was respectively assessments as well as the time interval of 24 hrs between the efforts mentioned. For the determination of CV, a linear regression between running velocity and inverse Tlim ($Tlim^{-1}$) was performed. The CV corresponded to the linear coefficient (y-intercept) of the regression equation.

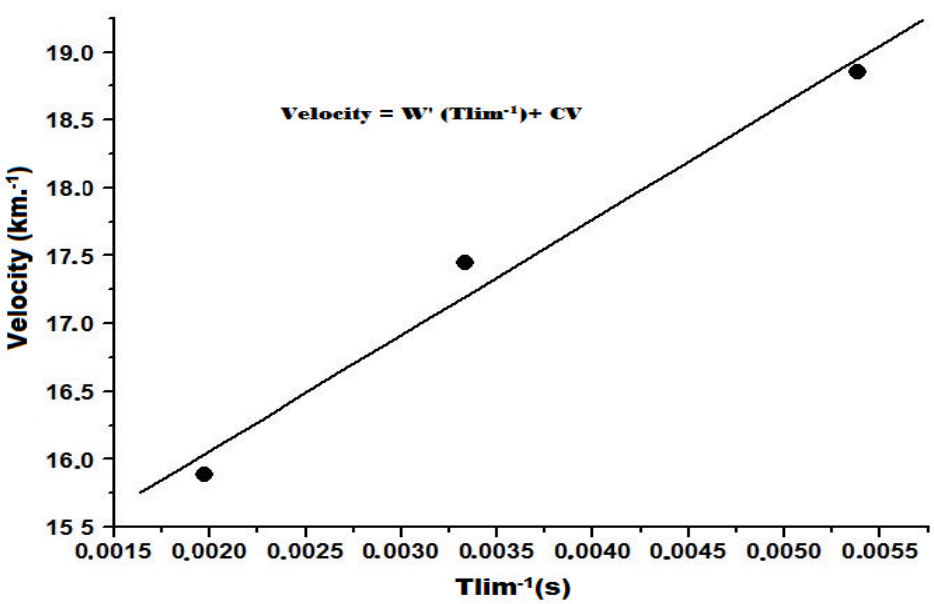

Figure 1. Representative model for the determination of CV by linear regression analysis between the velocity ($km{\cdot}h^{-1}$) and $Tlim^{-1}$ (s).

Performances Field 1200, 2400, and 2800 M: The determination of performance during the distances of 1200 (P1200), 2400 (P2400), and 2800 m (P2800) runs were performed on an official running track with a 24-hr interval laboratory tests and the same period of time with each other. The running performances were assumed to be performed at race velocities ($km \cdot h^{-1}$), which were determined by means of a digital chronometer (Timex, TI5G811® Manaus, Brazil).

Statistical Analyses

Values are present as descriptive statistics consisting of means ± standard derivations. Initially, the Shapiro Wilk's normality for all variables was applied, and from that moment, a parametric statistical analysis test was used. To verify the correlation between laboratory tests with performances running test, the Pearson correlation was used with significance level pre-set at P=0.05. For all statistical analyses, the Statistica 7.0 (Statsoft, Tulsa, USA) was used.

RESULTS

Table 1 shows the mean and standard deviation at VO_2max and the mean the velocities vVO_2max and CV and the maximum performance in the field P1200, P2400 and P2800. The average VO_2max obtained in maximal incremental test was equivalent to 57.96±4.23 $ml \cdot kg^{-1} \cdot min^{-1}$, while the vVO_2max average corresponded to 16.03 ± 0.84 $km \cdot h^{-1}$. In the CV test was obtained a coefficient of determination in the linear regression 0.94±0.05, while the CV corresponded to 14.35±1.10 $km \cdot h^{-1}$.

Table 1. Descriptive Data Presented as Mean ± Standard Deviation for Maximal Oxygen Uptake (VO_2 max), Minimal Velocity at which VO_2 max is attained (vVO_2max), Critical Velocity (CV), 1200 M Performance (P1200), 2400 M Performance (P2400), and 2800 M Performance (P2800).

Runners	VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$)	vVO_2 max ($km \cdot h^{-1}$)	CV ($km \cdot h^{-1}$)	P1200 (s)	P2400 (s)	P2800 (s)
Mean	**57.96**	**16.03**	**14.35**	**233**	**514**	**611**
±SD	**4.23**	**0.84**	**1.10**	**15**	**31**	**35**

Table 2 presents the correlation coefficients between the variables obtained from laboratory tests, VO_2 max, vVO_2 max, and CV with the velocities of the performances obtained on the track (P1200, P2400, and P2800). The vVO_2 max and CV were significantly correlated with all velocities for these distances while the VO_2 max correlated with only P2400.

Table 2. Pearson Correlation Coefficient Between the VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$), vVO_2 max ($km \cdot h^{-1}$), CV ($km \cdot h^{-1}$) and Velocities of P1200 ($km \cdot h^{-1}$), P2400 ($km \cdot h^{-1}$), and P2800 ($km \cdot h^{-1}$) Performances.

Performances	VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$)	vVO_2 max ($km \cdot h^{-1}$)	CV ($km \cdot h^{-1}$)
P1200	-0.58	-0.87*	-0.70**
P2400	-0.61	-0.86**	-0.81**
P2800	-0.52	-0.85**	-0.82*

*Significant correlation (P<0.05) **Significant correlation (P<0.01)

DISCUSSION

The results of this study show that the P1200, P2400, and P2800 measured during a field test can be used to satisfactorily predict vVO_2 max and CV using predictive load in maximum and supramaximal intensities determined in the laboratory. These findings are important because they show that the laboratory tests are interesting alternatives in the prediction of aerobic performance.

The VO_2 max values reported by Gaeni et al. (12) with runners were similar (58±2.8 $ml \cdot kg^{-1} \cdot min^{-1}$) to the values found in this study (57.96±4.23 $ml \cdot kg^{-1} \cdot min^{-1}$). However, the vVO_2 max of (19±0.29 $km.h^{-1}$) reported by Gaeni et al. (12) was superior to that obtained with the runners in our study (16.03±0.84 $km \cdot h^{-1}$) (Table 1). These results are in agreement with the literature, where athletes have similar rates of VO_2 max but not necessarily have the same intensities vVO_2 max (2).

We did not find significant correlations between the VO_2 max and P1200 (r= -0.58; P=0.17), P2400 (r=-0.61; P=0.26), and P2800 (r=-0.52; P=0.38). Thus, we believe that the VO_2 max is not likely to be a good predictor of aerobic performances. These results can be compared to the work of Denadai (7), where VO_2 max (when verifying in homogeneous groups of athletes) was not a good physiological predictor of the athletes' aerobic performance. Also, later, it was reported that VO_2 max did not justify such a significant change in aerobic performance at distances of 1500 and 5000 m (8).

Table 2 shows high inverse correlations between vVO_2 max with P1200 (r=-0.87; P=0.01), with P2400 (r=-0.86; P=0.01), and with P2800 (r=-0.85; P=0.01). This shows that vVO_2 max appears to be a reliable criterion in predicting aerobic performance, which is also in agreement with other studies in the literature (1,11,19,29). Hence, in the present study, vVO_2 max is the variable that best correlates with aerobic performance. This finding reinforces the work of earlier studies that also found vVO_2 max is a good tool to predict the performances of between 1500 and 10 km endurance races (1,13,25). Our results are consistent with the trend of presenting vVO_2 max association with endurance exercise at high intensities (12) with considerable anaerobic contribution (1500 meters) (3), aerobic effort in 3 km (r=0.70 and r=0.86), and VO_2 max and vVO_2 max (13), respectively.

Table 2 also shows a high inverse correlation of CV with the three aerobic performances. This model, as well as vVO_2 max, has been proposed as a tool for prescribing, monitoring, and training aerobic-predominant races (30) as well as a sensitive physiological parameter to evaluate variations in training endurance athletes (10,20). Since there are several published studies that demonstrate the affinity of CV to determine the aerobic capacity in several sports such as swimming (27), rowing (20), and canoeing (24), the values shown in this correlational study of CV with the field performances were expected. Also, given that Florance and Weir (10) examined 12 marathon runners of the New York city (231.9±27.4 min) and found by simple linear regression a significant correlation (r=0.76) of CV with the marathon running time, it is more than reasonable to suggests that CV can be an attractive field trail to evaluate the performance capacity in runners.

CONCLUSIONS

The results showed significant correlations for P1200, P2400, and P2800 with CV (r = -0.70) and vVO_2 max (r = -0.85). Thus, based on the results of this investigation, we conclude that CV and vVO_2 max determined in the laboratory can be used to predict performance in the distances studied in military runners.

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