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Critical velocity estimates running velocity in a 10-km running race in recreational runners

A velocidade crítica estima a velocidade de corrida em uma prova de 10-km em corredores recreacionais

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Abstract – The aim of this study was to compare the estimated running velocity in a critical velocity (CV) test with the real running velocity in a 10-km race. This is a cross-sectional study with a convenience sample of 34 runners, 20 males and 14 females (42,4 ± 11,0). The participants attended two days of testing and one day to participate in an official 10-km race. During the visits, the following tests were performed: i) 400-meter running track test and ii) 2000 meter running track test. They were randomly selected and held in official athletics track with at least 48 hours rest between them. The athletes were instructed to participate in the study properly recovered, fed and hydrated. The CV was calculated as the linear relation between distance and race time, corresponding to the slope of the linear regression line. Both tests occurred in similar climatic situations. We found good agreement between the velocities estimated through the CV test and the real running velocity of a 10-km race. Although there was a difference in velocities estimated by the CV test and the real 10-km race, the variation delta was low. Thus, these data indicate that the CV test seems to be a good tool for estimating the velocity of a 10-km race. The CV determined in the field with two fixed distances 400 and 2000 meter was valid to estimate the running velocity of a 10-km race.

Key words: Endurance training; Running; Track and field.

Resumo – *Objetivou-se comparar a velocidade de corrida estimada em um teste de velocidade crítica com a velocidade real de corrida em uma corrida de 10 km. Estudo transversal com amostra de conveniência de 34 corredores, sendo 20 do sexo masculino e 14 do feminino (42,4 ± 11,0). Os participantes participaram de dois dias de testes e um dia para participar de uma corrida oficial de 10 km. Durante as visitas, foram realizados os seguintes testes: i) pista de atletismo de 400 metros e ii) pista de corrida de 2000 metros. Eles foram selecionados aleatoriamente e mantidos em pista de atletismo oficial com pelo menos 48 horas de descanso entre eles. Os atletas foram instruídos a participar do estudo devidamente recuperados, alimentados e hidratados. A velocidade crítica (CV) foi calculada como a relação linear entre distância e tempo de corrida, correspondendo à inclinação da linha de regressão linear. Ambos os testes ocorreram em situações climáticas semelhantes. Boa concordância entre as velocidades estimadas através do teste CV e o tempo real de teste de 10 km. Embora tenha havido uma diferença nas velocidades estimadas pelo teste CV e o tempo real de teste de 10 km, o delta de variação foi baixo. Assim, esses dados indicam que o teste CV parece ser uma boa ferramenta para estimar a velocidade de uma corrida de 10 km. O CV determinado no campo com duas distâncias fixas de 400 e 2000 metros foi válido para estimar a velocidade de corrida de 10 km.*

Palavras-chave*:* Atletismo; Corrida; Treinamento aeróbio.

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INTRODUCTION

The number of recreational practitioners of long-distance running races increased significantly in several countries[1–3], in addition to seeking the improvement of physical fitness and health, also aims to better performance, which makes it necessary to identify methods and techniques in order to optimize training and performance[4]. This makes the interest of the scientific community increase concerning the understanding of the physiological variables that can potentially improve performance[5].

In addition to the various physiological variables, other factors may influence performance, such as the running duration, anthropometric parameters, running strategy, age, sex, nutrition, and supplementation[6]. During running races, endurance athletes generally adopt strategies with a velocity distribution consisting of distinct phases throughout the running[6]. Nevertheless, some athletes try to maintain the same rhythm from the beginning to the end of the run, which does not mean to maintain the same physiological requirement, since the geo-climatic factors and the accumulated wear throughout the running interfere in the performance and increase the physiological demand[4]. Thus, the intensity of the running might change during tests of medium to long-distance, which can sometimes compromise energy reserves, particularly in the final part of the running[7]. In this perspective, studies to understand running velocity become important to promote better test strategies and periodization preparation[7,8].

There are several field and laboratory procedures for the determination of running velocity. Laboratory tests are usually done in controlled environments and have good measurement accuracy. However, they exhibit disadvantages such as high cost, little or no specificity, and low external validity. Field tests, on the other hand, are less costly, easier to apply, and approximate to the reality of athlete competition, although there may be suspicions about reliability and trustworthiness. Among field tests, critical velocity (VC) has been widely used and seems to predict running velocity[4,9–11]. Its definition is understood as the intensity of effort limitation that can persist with the stable kinetics of oxygen and lactate consumption, that is, the accumulation of blood lactate produced by the active muscle is similar to its rate of clearance in muscle and other tissues, and may correspond to the velocity of the anaerobic threshold[12]. Nevertheless, there will always be an error of estimation of VC, which may vary slightly on different days in the same individual[13].

Therefore, it becomes clear the importance to know the running velocity, mainly through simple tests, low cost, and good accuracy, since its identification can help runners during long-distance running races. Thus, the objective of the present study was to compare the estimated running velocity in a CV test with the real running velocity in a 10-km race. We hypothesize that the CV, identified from the 400- and 2000-meter tests on the athletics track, can predict running velocity in recreational runners.

METHOD

Sample and ethical criteria

A cross-sectional study with a convenience sample of 34 runners, 20 males and 14 females (42.4 ± 11.0). The study was approved by the Research Ethics Committee of the Catholic University of Brasília (opinion no. 2,109,629 / 2017) and the participants signed the institutionally approved informed consent document (IAICD).

Inclusion criteria

Only those with running experience, above 18 years of age, who had participated in at least one 10-km race competition, asymptomatic for any health problem, and able to perform the physical tests were included in the study. They should be training uninterruptedly for at least 6 months, sign the IAICD, participate in all moments of the study, and do not use any medication that could alter cardiac functions.

Procedures

The participants attended two different days of testing and one day to participate in an official 10-km running race. During the visits, the following tests were performed: i) 400-meter running track test and ii) 2000 meter running track test. They were randomly selected and held in official athletics track with at least 48 hours rest between them. The athletes were instructed to participate in the study properly recovered, fed, and hydrated. Both tests occurred in similar climatic situations (temperature 21-26 ° C, relative humidity = 50-70%).

Body composition

Body fat was measured using dual-energy X-ray absorptiometry (DXA). Volunteers were asked to remove any metallic items they were wearing, such as rings, jewelry, belts, and watches (because such objects affect the values of the estimated variables). Volunteers were placed in horizontal decubitus dorsal on the DXA apparatus for full-body analysis. The equipment used was a Lunar DPX-IQ with version 4.6A software. Before, the DXA equipment was duly calibrated, according to the manufacturer recommendations, and cut line adjustments were predefined. All analyzes were performed by the same measurer.

Critical velocity

For the determination of the CV, the times of the 400- and 2000-meter tests on an official athletics track were recorded. Subjects were instructed to run the set distances, alone, in the shortest time as possible. The CV was calculated as the linear relation between distance and race time, corresponding to the slope of the linear regression line. The tests were performed at 08:00 AM or 19:00 PM[12].

Statistical analysis

Initially, data normality data was verified through the Shapiro-Wilk Test. Data are presented by the mean and standard deviation. The independent t-test was used to compare means according to sex. The paired t-test and the Bland-Altman plot were used to make the comparisons and concordances between the velocity estimated by the CV and the real velocity in the 10-km race, respectively. The upper and lower limits of agreement were set with an alpha of 95% (± 1.96 standard deviation). The intraclass correlation coefficient (ICC) and the Cronbach's alpha were calculated to evaluate the reproducibility between the CV test and the real 10-km race velocity. The ICC values were interpreted as low if <0.40, moderate between 0.40 and 0.75, and excellent> 0.75, according to the scale of reliability levels proposed by Fleiss[14]. Also, the values of total error (TE), constant error (CE), and standard error of estimation (SEE) were calculated. The value of p <0.05 was adopted to indicate significant differences. The SPSS program, version 18.0, was used for the analyzes.

RESULTS

Table 1 shows the results of the characterization of the sample for the total group and stratified according to gender.

Table 1. Characterization of the sample.

	Total (34)	Male (20)	Female (14)
Age (years)	42.4 ± 11.0	41.4 ± 12.7	43.7 ± 8.9
Weight (kg)	65.7 ± 9.0	68.8 ± 9.2	61.1 ± 7.0 *
Height (m)	1.69 ± 0.8	1.72 ± 0.8	1.64 ± 0.4 *
BMI (kg/m²)	25.8 ± 6.5	27.7 ± 6.8	23.1 ± 5.4 *
Body fat (%)	15.9 ± 6.5	10.7 ± 4.8	23.1 ± 8.0 *
Maximum speed(km/h)	14.1 ± 2.0	15.4 ± 1.3	12.3 ± 1.3 *
MHR (bpm)	180.5 ± 8.9	180.3 ± 10.6	180.6 ± 7.8
AT_{VO2} (ml/kg/min)	43.5 ± 7.3	47.9 ± 3.6	36.7 ± 6.7 *
AT_{speed} (km/h)	12.6 ± 1.8	13.7 ± 1.2	10.9 ± 1.0 *
AT_{HR} (bpm)	169.0 ± 10.4	169.3 ± 12.0	168.6 ± 9.4
AT_{RPE}	12.8 ± 1.9	12.5 ± 1.8	13.4 ± 2.3
10-km Race (min)	45.9 ± 7.3	41.5 ± 4.3	52.3 ± 6.2 *
10-km Race (km/h)	13.4 ± 2.1	14.6 ± 1.5	11.6 ± 1.3 *
CV (km/h)	13.9 ± 2.2	15.3 ± 1.4	11.9 ± 1.6 *

Note. * $p < 0,05$ female vs. Male. BMI – body mass index; MHR – maximum heart rate; AT_{Vo2} –oxygen consumption at the anaerobic threshold; AT_{speed} – the speed at the anaerobic threshold; AT_{HR} –heart rate at the anaerobic threshold; AT_{RPE} – ratings of perceived exertion at the anaerobic threshold; CV– critical velocity.

As seen in table 1, only age, MHR and ATHR did not differ between men and women.

Figure 1 presents the concordance values established by the Bland-Altman plot, with values presented for the total group and stratified by gender.

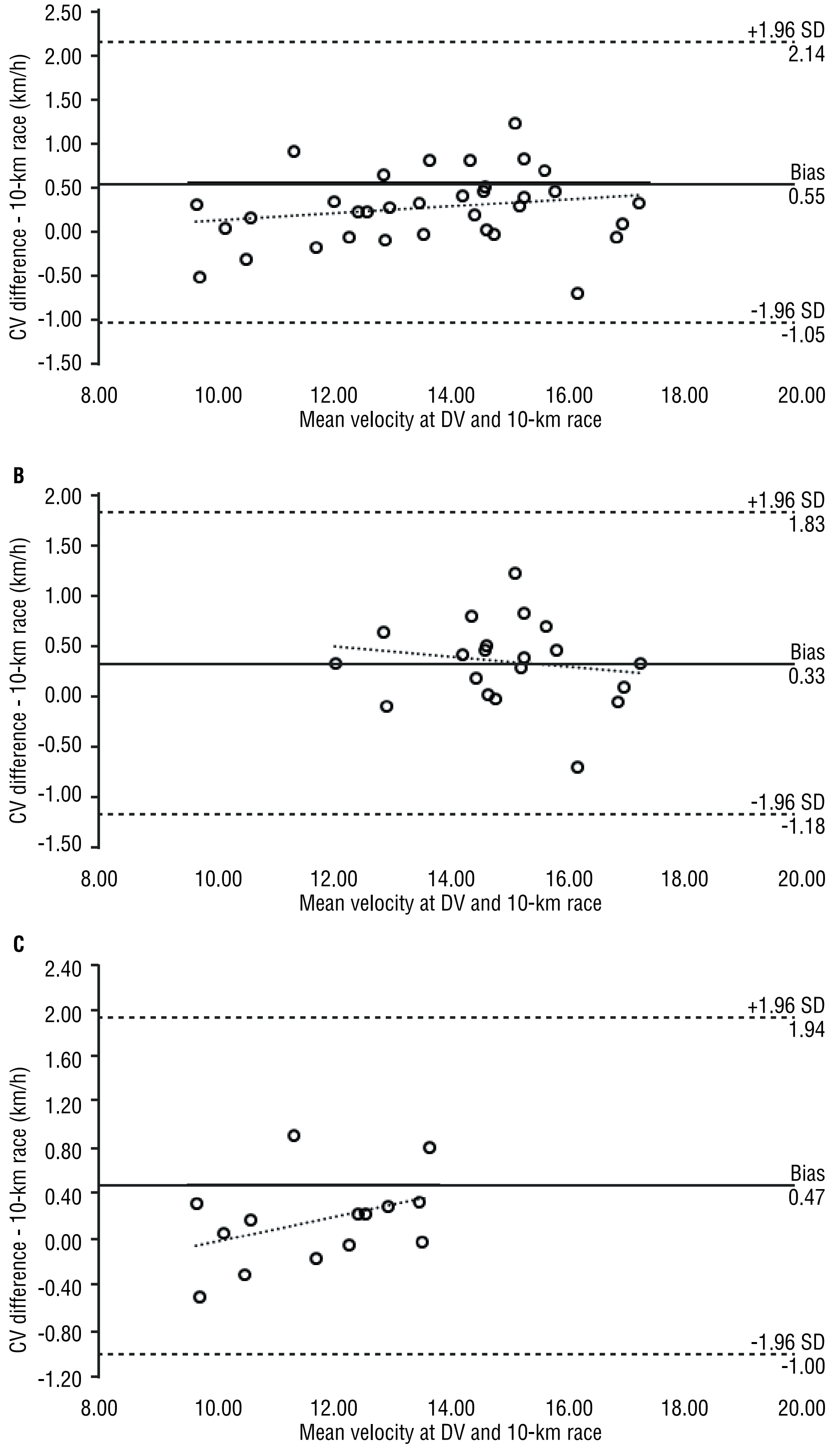

Figure 1. Agreement between the velocities estimated through the critical velocity test and the mean velocity of the 10-km race. A - total group, B - male and C - female.

As observed in figure 1, a good agreement was found between the velocities estimated through the CV test and the real 10-km running race. In most cases (total group, male and female) the values are within the established limits.

Table 2 presents the comparison of velocities estimated by the CV test and the real test time of 10-km, as well as the error and reproducibility values for the total group and stratified by gender.

Table 2. Comparison of sample rates.

	Total Group	Male	Female
Critical Velocity (km/h)	13.9 ± 2.2 *	15.3 ± 1.4 *	11.9 ± 1.6
10-km Race (km/h)	13.4 ± 2.1	14.6 ± 1.5	11.6 ± 1.3
Delta CV *vs* 10-km race (km/h)	0.5	0.7	0.3
ICC	0.90 (0.70 – 0.96)	0.74 (0.23 – 0.91)	0.86 (0.61 – 0.95)
Cronbach's Alpha	0.96	0.91	0.93
Correlation	0.93	0.83	0.88
Total Error	0.97	1.07	0.81
Constant Error	0.54	0.70	0.33
Standard Error of Estimation	0.29	0.44	0.27

Note. ICC - Intraclass Correlation Coefficient; * Significant difference between Critical Velocity and 10-km Race, $p < 0.05$.

As verified in table 2, mean velocity values estimated through the CV test and the real test time of 10 km differed in the total group and the male group, but there was no difference in the female sex since the between the velocities compared in the present study. The reproducibility between the velocities calculated by ICC and Cronbach's Alfa presented high values and considered excellent, according to the classification of ICC reference values. Besides, the values presented by the calculation of the CE and SEE were lower than 0.7 and 0.44 km / h, respectively.

DISCUSSION

The main results of the present study show a good agreement between the velocities estimated through the CV test and the real 10-km race. Although there was a difference in velocities estimated by the CV test and the real 10-km race, the variation delta was low. Thus, these data indicate that the CV test seems to be a good tool for estimating the velocity of a 10-km running race.

Denadai *et al.*[10] have used non-invasive and easy-to-apply protocols, in which the effectiveness of the use of mathematical models to identify CV from the distance-time relationship in performance tests performed in running are highlighted. Our results also partially corroborate the findings of another study[4] who associated CV with the performance on the 3.6-km climb, 10 and 21-km in men and women. And they verified that CV was high and significantly associated with all distances studied, proving to be an adequate predictor of aerobic performance.

Because it is an indicator of aerobic fitness, it is believed that CV can be influenced by training sessions with aerobic characteristics. This behavior has been presented by several studies that indicated improvements in CV after training periods of three to eight weeks, all performed in a cycle ergometer[4,14–17]. These results, besides corroborating with the findings of this study, demonstrate the efficiency of the use of CV as a physiological indicator to provide cardiovascular and metabolic improvements and to be sensitive to aerobic training programs.

One study verified the validity of CV for the determination of the effects of anaerobic threshold training in endurance athletes and confirmed that CV had good validity for the determination of AT before but not after a four-week training program[10]. Similar results were found in another study[9], which evaluated the CV, the maximum steady-state velocity of lactate, and the speed at the lactate threshold in eight males with a mean age of 28 years, with no differences between speeds. Thus, the use of CV is useful for assessing effort tolerance in different intensity domains, for training prescription and for predicting performance.

Regarding applicability, the present study verified that the CV determined on the track with only two distances (400 and 2000 meter) may be valid to determine the speed obtained in endurance runners in a 10-km running race. However, coaches and physiologists should monitor runners' performance throughout periodization as there appears to be a tendency for women to underestimate and for men to overestimate the difference between CV and the 10-km running velocity as performance increases, as can be seen by the trend line shown in Figure 1B and 1C. Also, other studies have shown that CV is a good parameter for the training prescription, which allows the rider to have a reliable measure to determine his possibilities of performance and to follow the race rhythm during tests of 10-km. Besides, its use as a specific and individualized evaluation method, in which it does not require expensive and sophisticated equipment, which at the same time makes its application easier and can be used in environments of athletics tracks, fields, among others[18]. Moreover, a simple AT test, using blood lactate determination versus an incremental test, requires the use of sophisticated equipment that is not always accessible to recreational runners. Thus, CV seems to be a valid and easy-to-apply alternative tool that can be used by coaches, runners, and clubs with limited financial resources.

The CV, as well as the AT, is sensitive to the changes induced by training, and that commonly occurs the intensity of exercise similar to the maximum stable phase of lactate[19] there is a dynamic balance between biochemical factors (such as blood lactate, bicarbonate and, pH) and ventilatory parameters, thus occurring a metabolic transition point[19–21]. Thus, the search for new indexes capable of predicting physical performance is extremely necessary, once from them it is possible to prescribe aerobic training programs more efficiently, in addition to indicating the more precise evaluation of the effects of the training developed. Data from this study support that CV appears to be sensitive to estimate long-distance running velocity (e.g. 10-km) in recreational runners. However, although it seems to be an adequate tool for predicting performance, there is still a need for further research and further studies on the CV for this purpose.

One limitation of the present study was the non-performance of all tests at the same time, however, the distribution of the tests was randomized, except for the 10-km race. Moreover, there were no climate changes during the tests. Another limitation is the impossibility of ensuring that the athletes complied with the recommendation not to perform vigorous exercises 48 hours before each experiment, however, messages and phone calls were made to the athletes remembering the need to follow the recommendations before the tests.

CONCLUSION

We concluded that the CV determined in the field with two fixed distances, 400 and 2000 meters, was valid to estimate the running velocity of a real 10-km race. Additionally, a good agreement was observed through the intraclass correlation. Therefore, this study provides evidence that CV can be used to estimate the running velocity of a 10-km race for recreational runners.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

This study was approved by the Research Ethics Committee of the Catholic University of Brasilia – DF – Brazil (CAAE: 2.109.629 / 2017). This research is in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: HLC; HSR and APF. Performed the experiments: HCL and HSR. Analyzed the data: HLC; APF; VAC and VMB. Contributed reagents/materials/analysis tools: APF; RNBF; THBV. Wrote the paper: HLC; HSR; APF and RVPN.

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