

USE OF MAXIMAL RUNNING DISTANCE PERFORMED ON HOFF TEST FOR ANAEROBIC THRESHOLD PREDICTION IN SOCCER



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ABSTRACT

Objective: The purpose of the study was to verify the use of maximal running distance performed on Hoff test to predict anaerobic threshold speed (sAnT). **Methods:** Ten young soccer players (age of 17 ± 1 years and body mass of 64.3 ± 2.1 kg) were subjects of the study. The subjects performed 12-min test, lactate minimum test to estimate anaerobic threshold speed and a field test called Hoff. The purpose of Hoff test was to cover the maximum distance during a period of 10min moving a soccer ball through the track by dribbling. **Results:** The distance covered during 12-min was 2673.2 ± 64.7 m, the sAnT was 11.6 ± 0.3 km.h⁻¹ and distance covered during test Hoff test was 1458.7 ± 49.6 m. The distance covered during Hoff test was not significantly correlated with sAnT ($r = -0.20$; $P > 0.05$) and distance covered during 12-min test ($r = -0.15$; $P > 0.05$). The sAnT did not differ of speed correspondent 90% at 12-min speed and they were statistically correlated ($r = 0.65$). **Conclusion:** Thus, we concluded that maximal distance covered during Hoff test cannot provides a valid prediction of the anaerobic threshold speed.

Keywords: physical endurance, lactate, anaerobic threshold, soccer.

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INTRODUCTION

Soccer is considered a complex sport which demands excellent improvement of the motor skills, such as aerobic capacity, aerobic capacity, strength and flexibility¹, besides technical skills. In the current soccer, this capacity is increasingly demanded, especially concerning aerobic capacity. Nowadays, it has been verified that an elite soccer player covers from 10 to 12 km during one match, which is much more than the total distance covered during a match some decades ago. Such fact evidences the increase in physical demand during the game and the importance of the aerobic resistance in the physical performance of the athlete. Aerobic fitness in soccer is responsible both for the energy supply in the endurance events, which are predominant in the game, and for the fast recovery after an anaerobic activity²⁻⁴.

Aerobic fitness has been usually determined by the anaerobic threshold, which corresponds to an index of aerobic capacity, and by the maximal oxygen uptake (VO_{2max}), which corresponds to an index of maximal aerobic power. However, although the VO_{2max} is a 'classical' procedure in the evaluation of aerobic fitness^{5,6} in well-trained athletes, the VO_{2max} does not seem to present good sensitivity for detection of the adaptations derived from training. Thus, the determination of the anaerobic threshold through the lactacidemic responses^{4,7-9} has been widely used.

Nevertheless, despite the excellent validity of these procedures for the evaluation of aerobic fitness, the main criticism concerning these laboratory procedures is that the movements performed in the tests are not specific to the movements performed during the soccer game.

As an alternative to the limitation of specificity in the test,

Hoff *et al.*¹⁰ proposed an aerobic training circuit specific to soccer, which involves runs in varied directions, jumps and dribbling, always with the ball conduction and which makes it possible to reproduce during the circuit many of the activities performed during the game. Subsequently, this circuit was used as an evaluation procedure of aerobic fitness¹¹, being verified significant correlations between the maximum distance covered in 10 minutes in this circuit with the VO_{2max} ($r = 0.68$), besides making aerobic improvement possible (improvement of 9.6% in the circuit performance) and being sensitive to the alterations occurred after eight weeks of training.

However, as previously mentioned, the anaerobic threshold has presented higher sensitivity concerning the VO_{2max} in the evaluation of the aerobic component, and hence, the possibility to predict the anaerobic threshold through the distance covered in the Hoff test (circuit)^{10,11}, which reproduces many activities performed in soccer, would present high practical applicability in soccer. Thus, the aim of this study was to verify the use of the total distance covered in 10 minutes in the Hoff test¹¹ to predict the anaerobic threshold velocity measured through the minimum lactate test.

MATERIALS AND METHODS

Participants

10 young soccer players (aged 17 ± 1 year, bodyweight 64.3 ± 2.1 kg, height 171.9 ± 1.5 cm and fat percentage $14.7 \pm 1.4\%$), who have been engaged in regular and systematic training four times per week for at least four years participated in this study. The participants and their parents or legal tutors were told about the risks and benefits of the procedures and only participated

in the tests after having signed a Free and Clarified Consent Form. The experimental procedures used in the study, as well as the Free and Clarified Consent Form, were approved by the Ethics Committee of the State University of São Paulo (legal process 54-210/2010).

The participants were submitted to the 12-minute test, the minimum lactate test and the Hoff test with 10-minute duration. Twenty-four hours before the Hoff test performance, the participants were familiarized with the exercise circuit. All tests were performed in the beginning of the season in the basic preparation period of the athletes.

12-minute test

The 12-minute test was applied on a 400 m track (marked every 50 m). The 12-min test consisted in covering the longest distance in 12 minutes. The participants were told about the time of the test only on the 11th minute through a sound signal. After the end of the test, the participants remained at the same place until the total distance covered in the test was measured, and the subject could only perform lateral movements. In this test, total covered distance, mean velocity ($v_{12 \text{ min}}$) and velocity corresponding to 90% of $v_{12 \text{ min}}$ ($v_{90\% v_{12 \text{ min}}}$) were determined.

Minimum lactate test for anaerobic threshold velocity determination (v_{LAn})

The minimum lactate test was applied on the 400-meter track, which was signaled with cones at every 50 m. Initially, maximal exercise of 300 m was applied to induce hyperlactacidemia. After eight minutes of passive recovery, the athletes were submitted to an incremental test, with exercise stages of 800 m. In the incremental test, the initial intensity corresponded to 4 km/h lower than $v_{90\% v_{12 \text{ min}}}$, which was increased in $2 \text{ km}\cdot\text{h}^{-1}$ after each exercise stage (800 m). The exercise velocity control was performed through sound signals at every 50 m in order to help the subject control and keep the pre-set intensity. A 60 s pause after each exercise stage was standardized for blood samples collection. The blood samples were collected at minutes three, five and seven after the 300 m race, immediately after each exercise stage and after the five and seven minutes after the last exercise. The anaerobic threshold velocity (v_{LAn}) (estimated by the minimum lactate test) corresponded to the zero derivate of the polynomial adjustment of second degree between intensity and lactate.

The blood samples (25 μl) were collected from the earlobe using glass capillaries for micro-hematocrit previously calibrated, stored in Eppendorf tubes containing 50 μl of sodium fluoride at 1% and later analyzed in electrochemical lactometer YSI 1500 Sport (Yellow Spring Instruments, Ohio, USA).

Adapted Hoff Test

The Hoff test consisted of a maximal exercise with 10-minute duration in a circuit with 290 m of distance, divided in three stages, comprising respectively, the 49, 186 and 55 m distances. The entire circuit was performed with the participant conducting the ball. On the first stage the subjects covered 10 m conducting the ball in a straight line and forward dislocation, followed by 18 m of zig-zag dislocation within the cones placed at every 2 m, simulating dribbling, ending in forward dislocation for 29 m, jumping three

30-35 cm high hurdles at every 7 m. On the second stage, after jumping the second hurdle, the participants performed a diagonal race until one cone placed 36 m away, and from that moment on, performed six extra diagonal dislocations in a path containing 25 m each, with a total of 186 m. On that stage, the participants completely surrounded the cones conducting the ball. When arriving at the last cone, the third stage of the circuit was initiated and from that moment a 10 m distance was performed with backwards race until the site marked by two cones. Subsequently, the athletes performed forward race for 15 m, and finally, a 30 m distance to end the circuit. A representation model of the used circuit in the Hoff test, with the hurdles and the covered distances in each activity, is presented in figure 1.

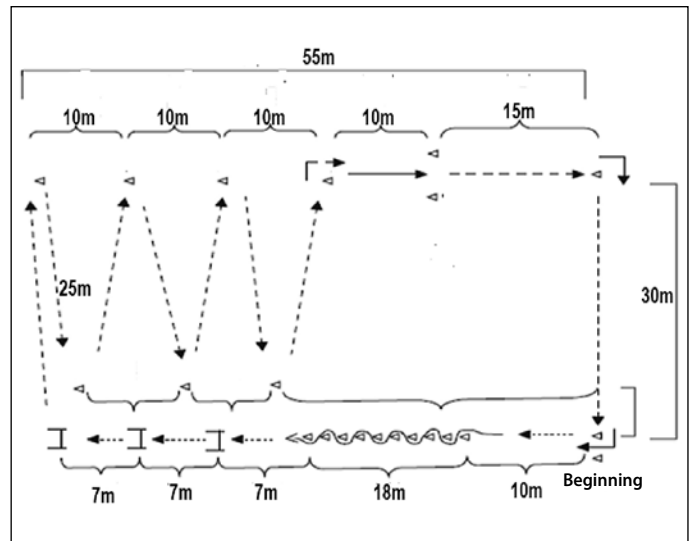


Figure 1. Chart representing the circuit used for the Hoff test. In the sites of dislocation represented by dotted arrows ($\cdots\rightarrow$), forward runs were performed; in the site represented by continuous arrow, a backward run was performed (\rightarrow). There were also sites in the circuit where it was necessary to perform obstacle jumps (\equiv) at every 7 m and also dribbling simulation through cones placed every 2 m of distance ($\text{---}\text{---}\text{---}$). Adapted from Hoff et al.¹⁰

Statistical analysis

The results are presented in mean \pm standard error mean. Initially, the normality and homogeneity tests of the data were performed through a Shapiro-Wilk test. After normality has been confirmed, parametric statistics was applied. The Pearson correlation test was used to verify the correlation between the obtained results in the Hoff test with anaerobic threshold and distance covered in the 12-minute test. Analysis of variance for repeated measures (ANOVA) was applied for analysis between the v_{LAn} , $v_{12 \text{ min}}$ and $v_{90\% v_{12 \text{ min}}}$. The Newman-Keuls post-hoc was used in case the F value was significant. The simple linear regression procedure was used to design possible prediction equations of the anaerobic threshold compared with other parameters. Analysis of concordance between variables was verified by Bland-Altman plot. Significance level of 5% was considered for all cases.

RESULTS

The total distance covered in the 12-minute test was $2,673.2 \pm 64.7 \text{ m}$, which resulted in mean velocity of $13.4 \pm 0.3 \text{ km}\cdot\text{h}^{-1}$, while $v_{90\% v_{12 \text{ min}}}$ was $12.0 \pm 0.3 \text{ km}\cdot\text{h}^{-1}$. In the minimum lactate test,

the time obtained in the 300m maximal race was 46 ± 0.8 s, which resulted in lactate concentration peak of 11.1 ± 0.5 mmol.l⁻¹. The anaerobic threshold intensity estimated in the minimum lactate test was 11.6 ± 0.3 km.h⁻¹, which was not statistically different from v90% v12 min; however, both were higher than v12 min ($P = 0.000$). The lactate concentration in that intensity was 7.0 ± 0.5 mmol.l⁻¹.

The distance covered in the Hoff test was $1,458.7 \pm 49.6$ m and mean velocity in that test was 8.8 ± 0.3 km.h⁻¹. The total distance covered in the Hoff test was not significantly correlated with vLAn ($r = -0.20$; $P = 0.575$) and with the distance covered in the 12-minute test ($r = -0.5$; $P = 0.679$). Nevertheless, significant correlations were verified between vLAn with total distance covered in the 12-minute test ($r = 0.65$; $P = 0.031$) and with v90% v12 min ($r = 0.65$; $P = 0.031$). Moreover, the Bland-Altman plot presented good concordance between vLAn and v90% v12 min (figure 2). Linear regression between vLAn and v90% v12 min is presented in figure 3.

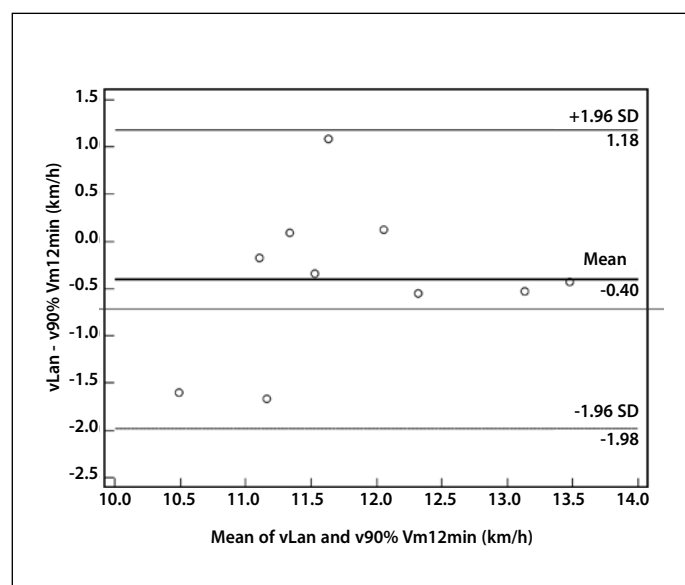


Figure 2. Concordance analysis between anaerobic threshold velocity (vLAn) and the velocity corresponding to 90% of v12 min (v90% v12 min) verified by Bland-Altman plot.

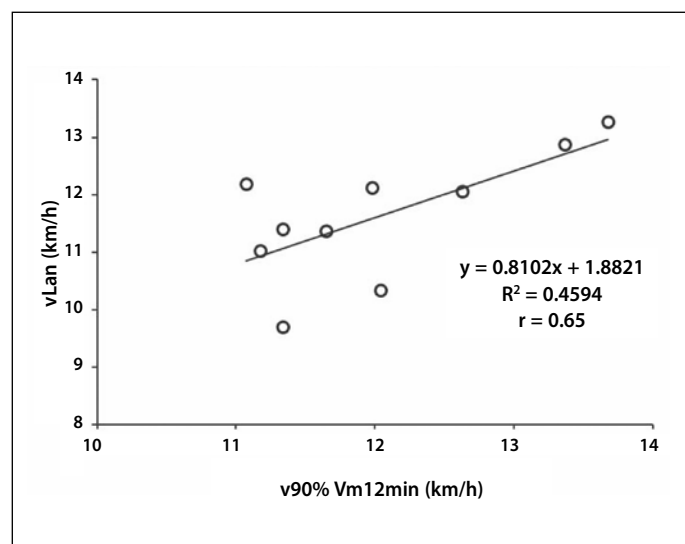


Figure 3. Linear regression between anaerobic threshold velocity (vLAn) and the velocity corresponding to 90% of v12 min (v90% v12 min), presenting the straight-line equation, the coefficient of determination (R^2) and the correlation coefficient (r).

DISCUSSION

The main finding of the study was the verification that the total distance covered in the Hoff test was not able to predict the anaerobic threshold velocity. However, it was observed that the v90% v12 min can be a good predictor of vLAn.

In the current soccer, the aerobic system plays an important role in the player's performance, being this energetic system the predominant in the energy supply in most part of the match^{3,12} and it also enables fast recovery of the anaerobic systems after high-intensity exercises²⁻⁴. Thus, the aerobic capacity (anaerobic threshold), which corresponds to the highest exercise intensity which presents aerobic predominance and is identified by the highest intensity at which balance between lactate production and removal (maximal lactate steady state) occurs, plays an important role in the physical performance of soccer players. The maximal lactate steady state test has been considered gold standard in the identification of the anaerobic threshold, also known as aerobic capacity¹³. However, there are many other procedures which estimate the vLAn in faster, simpler and more valid tests, such as the minimum lactate test used in the present study^{8,9,14,15}.

Non-invasive procedures which can estimate the aerobic fitness of soccer players, such as the yo-yo test^{16,17}, shuttle run⁵ or even the 12 min test^{6,7}, which estimate aerobic power (VO_{2max}) and aerobic capacity (anaerobic threshold), respectively, can be found in the scientific literature. However, in the non-invasive procedures none physiological variable is measured; what is measured is only the exercise time or stage in which the athlete entered exhaustion. Thus, the determination of the aerobic fitness may suffer influence of the motivational state of the subject to perform the test. Therefore, the minimum lactate test, for identifying the anaerobic threshold intensity through the lactacidemic response, becomes more accurate and more recommended for this purpose, being used as gold standard procedure in the present study.

The circuit proposed by Hoff *et al.*¹⁰ was designed with jumps, dribbling, dislocations in many directions, always with the ball conduction, to try to simulate the activities performed during the game, being the total distance covered in this test moderately correlated with the VO_{2max} ($r = 0.68$)¹¹.

Nevertheless, in the present study significant correlation was not verified between the distance covered in the Hoff circuit and the vLAn. In the Hoff circuit, besides the physical parameters (aerobic fitness), the player needs good technical skill specific to soccer to perform the test in shorter time. Moreover, since the maximal distance covered in 10 minutes of exercise is the dependent variable in this test, the motivational factor can also influence performance in the test. However, since the vLAn determination is performed by the measurement of the lactacidemic response, the only influence which can occur in the lactate response is derived from exercise, being less sensitive to error by psychobiological errors. However, it is wise to highlight that during a soccer match, the most part of dislocation is performed without ball. Thus, the task of conducting the ball in different directions and with dribbling and jumps, as performed in the Hoff test, seems to be much more dependent on technical than physiological parameters.

Ferreira *et al.*¹⁸ recently used the Hoff circuit to apply an incremental test with the purpose to determine the anaerobic threshold instead of a maximal 10-minute test; and compared this result with the maximal lactate steady state intensity (30-minute exercise sessions at rectangular intensity) also determined in this circuit. These authors verified that lactacidemia stabilization occurred in the anaerobic threshold intensity, while with the intensity increase this stabilization was lost, suggesting that it is possible to use an incremental test in the Hoff circuit to estimate the maximal lactate steady state. These findings corroborate the hypothesis that the maximum distance covered in the Hoff test with 10-minute duration is more influenced by technical parameters than physiological ones. Hoff *et al.*¹⁰, when suggested the circuit used in this study, described that this protocol could be used as training method to improve the VO_{2max} respecting many of the motor activities performed during the soccer game, which is very interesting for the practical application. However, the use of the maximal distance covered in the circuit to measure aerobic capacity should be revised.

The 12-minute test was used in the study to aid in the selection of the initial intensity to be applied in the minimal lactate test. The total distance covered in the 12-minute test has been used to predict the VO_{2max} ($VO_{2max} = [distance - 504]/45$), while Silva *et al.*⁷ proposed a linear regression equation to predict the anaerobic threshold velocity (determined with the use of the lactate steady concentration corresponding to 4.0 mmol.l⁻¹) using the v12 min. However, the exercise limit time at the intensity corresponding to the anaerobic threshold (maximal lactate steady state, minimal lactate and others) is equal too r higher than 40 minutes, where the maximal lactate steady state test itself uses exercise sessions with 30-minute duration¹³. Thus, the v12 min (maximum distance covered and time ratio) clearly presents value above the vLAN.

Thus, based on pilot studies in our laboratory in which we verified that the vLAN seems to occur in the velocity of approximately 90% of v12 min, the authors used this intensity in the present study. The previous findings of the authors were confirmed in this study, in which the vLAN estimated by the minimal lactate test was not significantly different from the v90% v12 min, being also verified significant correlation ($r = 0.65$) and good concordance between them, which was analyzed by the Bland-Altman plot. The Bland-Altman plot corresponds to an analysis of the residues between the difference of the two parameters by its mean. Thus, the mean of the difference (bias) between the vLAN and v90% v12 min corresponded to 0.4 km.h⁻¹, with low and high thresholds ($\pm 1.96 \times$ standard deviation) corresponding to -1.98 km.h⁻¹ and 1.18 km.h⁻¹, respectively. These results let us suggest the use of the 90% of v12 min velocity as a predictor of anaerobic threshold intensity in soccer.

CONCLUSION

We can conclude that the maximum distance covered in the Hoff test with 10-minute duration cannot be used for prediction of anaerobic threshold velocity, being this prediction possible due to the velocity corresponding to 90% of v12 min.

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All authors have declared there is not any potential conflict of interests concerning this article.

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