Assessment of the maximal aerobic speed in young elite soccer players

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Published in:
Science and Sports

DOI:
10.1016/j.scispo.2019.03.010

Publication date:
2019

Citation for published version (APA):
Los Arcos, A., Vázquez, J. S., Villagra Povina, F., Martín, J., Lerga, J., Sánchez, F., ... Zulueta, J. J. (2019). Assessment of the maximal aerobic speed in young elite soccer players: Université de Montréal Track Test (UM-TT) vs. treadmill test. Science and Sports, 34(4), 267-271. https://doi.org/10.1016/j.scispo.2019.03.010

Assessment of the Maximal Aerobic Speed in young elite soccer players: Université de Montréal Track Test (UM-TT) vs treadmill test

Abstract

Objective

The main aim of this study was to examine the association between the Maximal Aerobic Speed (MAS) measured by the Université de Montréal Track Test (UM-TT) and on a running treadmill test in young elite soccer players.

Equipment and methods Fourteen U-16 male soccer players (mean ± SD: age = 15.5 ± 0.7 years; height = 1.76 ± 0.5 m; weight = 67.7 ± 4.5 kg) from a Spanish First Division club academy participated in the study. The participants were submitted to the Université de Montréal Track Test (UM-TT) and an intermittent treadmill test with a one-week interval.

Results The MASs, the speed at the last completed stage (16.6 ± 0.8 $km \cdot h^{-1}$) and calculated using the formula of Kuipers et al. (17.2 ± 0.7 $km \cdot h^{-1}$), were substantially higher (Effect size > 0.8) than that measured on the treadmill (15.9 ± 0.9 $km \cdot h^{-1}$). The MAS measured by the UM-TT correlated highly (r > 0.6) with the MAS measured on the treadmill.

Conclusion Despite the large association between both values, the MAS measured by the UM-TT differs considerably from the MAS measured on a running treadmill in young elite soccer players. It suggests that, in soccer training, caution should be applied when using the velocity of the MAS measured on the UM-TT or in a laboratory interchangeably.

Key words: football; physical fitness performance; aerobic fitness; field test; laboratory test.

Résumé

Objectif L'objectif principal de cette étude était d'examiner l'association entre la vitesse aérobie maximale (VAM) mesurée par le test de la piste de l'Université de Montréal (UM-TT) et un test sur tapis roulant chez les jeunes joueurs de football d'élite.

Equipement et méthodes Quatorze footballeurs U16 (moyenne ± écart-type: âge = 15,5 ± 0,7 ans, taille = 1,76 ± 0,5 m, masse corporelle = 67,7 ± 4,5 kg) d'une académie d´un club de première division espagnole ont participé à l'étude. Les participants ont été soumis à l'examen sur piste de le test de l'Université de Montréal (UM-TT) et d un test intermittent sur tapis roulant avec un intervalle d'une semaine.

Résultats Les VAM, la vitesse à la dernière étape atteint achevée (16,6 ± 0,8 km · h^{-1}) et calculée en utilisant la formule de Kuipers et al. (17,2 ± 0,7 km · h^{-1}), étaient nettement plus élevés (ES > 0,8) que celle mesurée sur le tapis roulant (15,9 ± 0,9 km · h^{-1}). Le VAM mesuré par l'UM-TT est fortement corrélé (r> 0,6) avec le VAM mesuré sur le tapis roulant.

Conclusion Malgré la grande association entre les deux valeurs, le VAM mesuré par l'UM-TT diffère considérablement de la VAM mesurée sur un tapis roulant en cours d'exécution chez les jeunes joueurs de football d'élite. Ces résultats suggèrent que, lors de l'entraînement au football, il faut faire preuve de prudence lorsqu'on utilise la vitesse du VAM mesurée sur l'UM-TT ou dans un laboratoire de façon interchangeable.

Mots clés: football; performance physique; aérobie; essai sur le terrain; test de laboratoire.

Introduction

Maximal Aerobic Speed (MAS) constitutes a well-defined physiological identity that, together with maximal sprinting speed, determine the human locomotion profile [1]. MAS, the running speed which elicits maximal oxygen uptake (VO_2max), is a field-based measure that reflects a player's maximal aerobic power [2] integrated with his/her running economy [3]. It directly determines the relative neuromuscular load/strain that players encounter during soccer games and training sessions [4]. Therefore, this kind of information can be highly valuable when programming individual training plans and exercise intensities [2,5], as well as when monitoring training/competitive load [2].

Several methods have been proposed to evaluate MAS [5], but field tests are preferred due to the practical advantages. Field tests require little equipment, are easy to administer, and allow the evaluation of a large group of subjects simultaneously. Since Léger and Boucher [6] proposed the Université de Montréal Track Test (UM-TT), this and its modifications [7] are commonly used to assess the MAS in young soccer players. Although several studies carried out with adults showed that MAS measured by the UM-TT and on a treadmill were very similar and correlated highly ($r = 0.88 – 0.93$) [5,8,9], little is known about the association between these two methods on young soccer players. In a study performed with adolescents (8 males and 7 females) [10], there was no significant difference between the MAS measured by the UM-TT and on a treadmill, and the correlation between both velocities was very large ($r = 0.80$), but they were not involved in vigorous activities and were not especially trained in running.

Therefore, the main objective of this study was to examine the association between the MAS measured on the UM-TT and on a running treadmill in young elite soccer players.

Methods

Subjects

Fourteen U-16 male soccer players (mean ± SD: age = 15.5 ± 0.7 years, height = 1.76 ± 0.5 m, weight = 67.7 ± 4.5 kg), from a Spanish First Division club academy participated in the study. All players had a minimum of 8.5 years of experience in competitive soccer and competed for the same youth category at a national level. The Research Ethics Committee of the Navarra University Clinic (Clínica Universidad de Navarra) granted approval for the study. All players and parents were notified of the research procedures, requirements, benefits and risks before giving written informed consent.

Study design and procedures

The study was carried out immediately after the last competition match (i.e, June). With a one-week interval, the participants were submitted to the UM-TT [6] and an intermittent treadmill test [11] on the soccer pitch and in the laboratory, respectively. The players did not train during the week between the field and the laboratory tests. During both tests Heart Rate (HR) was recorded using short-range telemetry (Polar Team Sport System 2, Polar Electro Oy®, Kempele, Finland).

Treadmill protocol

The running protocol consisted of a progressive maximal exercise on the treadmill. The duration of each running stage was 4 min followed by a 1 minute rest interval. The initial speed was set at 10 $km \cdot h^{-1}$ (2.78 $m \cdot s^{-1}$) and it was increased by 1.5 $km \cdot h^{-1}$ (0.42 $m \cdot s^{-1}$) at each subsequent stage. The first three stages were used for warm-up, and testing continued until the subject could no longer maintain the required v [11]. Throughout the test, players were given verbal encouragement by the testers and coaches. During the test, respiratory gas exchange values were measured breath-by-breath using Vmax Encore metabolic cart (CareFusion, San Diego, USA). Both the metabolic cart and the treadmill were calibrated periodically following the manufacturer's recommendations. Immediately after the test, players rated their perceived level of exertion separately for respiratory and leg musculature effort [12] using Foster’s 0-10 scale [13]. This scale was applied during the previous four months in soccer training sessions so players were highly familiarized with it [14]. Moreover, capillary blood samples were taken immediately after each stage of the test by a standard puncture of a fingertip. Blood lactate concentrations were measured with the Lactate Scout+ (LS, SensLab GmbH, Germany).

Université de Montreal track test (UM-TT).

The UM-TT is a continuous, indirect and maximal multistage track test [6]. The speed of the multistage was initially set at 6.00 $km \cdot h^{-1}$; thereafter, the speed was increased by 1.20 $km \cdot h^{-1}$ by stages of 2-minute duration [6]. Players ran guided by cones placed at specific points on the field following instructions delivered with whistles. The test was stopped when the subject was at least 9 meters behind the appropriate cone at the sound signal or felt that he could not complete the stage [6]. Throughout the test, players were given verbal encouragement by the testers and coaches. The speed at the last completed stage measured with the UM-TT was considered to be the MAS [6] ($MAS_{UM\text{-}TT}$) in $km \cdot h^{-1}$. Furthermore, MAS was calculated using the formula of Kuipers et al. [15]: MAS = Sf + (t/60·0.5) ($MAS_{Kuipers}$), where Sf was the last completed speed in $km \cdot h^{-1}$ and t the time in seconds of the uncompleted stage. The VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) was assessed from both MASs (ie., VO_2max_{UM-TT} and $VO_2max_{Kuipers}$) with the formula of Léger and Boucher [6] where MAS was expressed in $km \cdot h^{-1}$: $VO_2max = 0.0324 \cdot (MAS)^2 + 2.143 \cdot MAS + 14.49$.

Statistical procedures

Descriptive results are presented as means ± standard deviations (SD). Practical significance was also assessed by calculating the Cohen's d effect size. Effect sizes (ES) between < 0.2, 0.2-0.6, 0.6-1.2, 1.2-2.0, and 2.0-4.0 were considered as trivial, small, moderate, large and very large, respectively [16]. Probabilities were also calculated to establish whether the true (unknown) differences were lower, similar or higher than the smallest worthwhile difference or change (between-subject SD/5, based on Cohen's effect size principle). Quantitative chances of higher or lower differences were evaluated qualitatively as follows: < 1%, almost certainly not; 1−5%, very unlikely; 5−25%, unlikely; 25−75%, possible; 75−95%, likely; 95−99%, very likely; > 99%, almost certain. If the chance of having higher or lower values than the smallest worthwhile difference were both > 5%, the true difference was assessed as unclear. Pearson's product-moment correlation coefficients were used to determine the relationships between the MAS (i.e. MAS_{UM-TT} and $MAS_{Kuipers}$) obtained on the UM-TT and the MAS assessed on the treadmill. The magnitude of correlation (*r* (95% Confidence limits)) between test measures were assessed with the following thresholds: < 0.1, trivial; 0.1 – 0.3, small; 0.3 – 0.5, moderate; 0.5 – 0.7, large; 0.7 – 0.9, very large; and 0.9–1.0, almost perfect [16]. In addition, the reliability was assessed using the Intraclass Correlation Coefficient (ICC) (95% Confidence limits) [16]. Data analysis was performed using a modified statistical Excel spreadsheet [17] and the Statistical Package for Social Sciences (version 19.0 for Windows, SPSS®, Chicago, IL, USA).

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Results

The MAS (i.e., MAS_{UM-TT} and $MAS_{Kuipers}$) obtained on the UM-TT were substantially higher (very/most-likely moderate/large) than on the treadmill (Table 1), while the estimated VO_{2max} were considerably lower (most-likely large/very-large) than the directly measured VO_{2max} (Table 1). The HRmax was 199 ± 6 on the UM-TT and 201 ± 7 on the treadmill (ES = 0.28 ± 0.17; 79/21/0 likely small). After the treadmill test, blood lactate concentration was 11.3 ± 2.3 $mmol \cdot l^{-1}$, while the respiratory and leg musculature efforts were 9.0 ± 1.0 and 9.2 ± 1.0 Arbitrary Units, respectively.

**** Tables 1 here ****

The MAS_{UM-TT} (Figure 1) and the $MAS_{Kuipers}$ obtained by the UM-TT correlated substantially with the MAS measured on the treadmill test, r = 0.67 (0.31 – 0.89, Very likely positive, p = 0.01) and r = 0.60 (0.19 – 0.83, Very likely positive, p = 0.03), respectively. ICC values were: MAS_{UM-TT} - Treadmill MAS, r = 0.66 (0.22 – 0.88, p = 0.00) and $MAS_{Kuipers}$ - Treadmill MAS, r = 0.58 (0.10 – 0.84, p = 0.01).

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**** Figure 1 here ****

Discussion

The aim of this study was to examine the association between the MAS measured on the UM-TT and on a running treadmill in young elite soccer players. The main findings were: a) while the field-MAS was most-likely greater (ES = large) than the laboratory-MAS, the VO_{2max} estimated by the UM-TT was most-likely lower (ES = large/very-large) than the VO_{2max} measured on the treadmill, and b) the association and the intraclass correlation between the MAS measured by the UM-TT and on treadmill were large.

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In previous studies, the field-MAS was slightly higher than treadmill-MAS within adult runners [8] but both speeds were not significantly different in adult physical education students [5,9]. In addition, the direct measurement of VO_{2max} and estimated VO_{2max} were similar [5,9]. However, in our study, field-MASs were most/very-likely greater (ES = moderate/large) than the laboratory-MAS, while the VO_{2max} estimated by the UM-TT using the formula proposed by Léger and Boucher [6] (i.e., $VO_2max = 0.0324 \cdot (MAS)^2 + 2.143 \cdot MAS + 14.49$) was most-likely lower (ES = large/very-large) than the VO_{2max} measured on the treadmill. It suggests that caution should be applied when: a) field-MAS and laboratory-MAS values are used interchangeably in soccer training to program individual training plans and exercise intensities [2,5] and to monitor training/competitive load [2], and b) the direct and estimated VO_{2max} measurements are compared in order to assess the aerobic fitness level of young soccer players. Among other factors, the type of treadmill test protocol [5,8,9], and the biomechanical requirements of each test [8,9] could explain these differences. Respect to the treadmill test protocol, the differences between UM-TT and treadmill test in the starting speed, increments and stage lengths could explain the substantial differences between field-MAS and laboratory-MAS and the contradictory results in comparison with the previous studies. However, in these studies the protocol of the UM-TT and of the treadmill test also were different [5,8,9]. Therefore, the age of the athletes (adults vs youth) could explain the differences between studies.

Several studies performed on adults showed a large association between the MAS measured on the UM-TT and on a treadmill [5,8,9]. Lacour et al. [8] and Berthoin et al. [5] found an almost perfect correlation (r = 0.92 and 0.93) between the $MAS_{UM\text{-}TT}$ and the MAS measured during an intermittent graded treadmill test with experienced runners (23 ± 5 years) and physical education students (22 ± 3 years), respectively. Similarly, Ahmaidi et al. [9] described a very large (r = 0.88) association between the $MAS_{Kuipers}$ and the MAS determined by the treadmill test (i.e. incremental progressive protocol) with physical education students (23 ± 1 years). In comparison with our study, although the association between the field-MASs and the treadmill-MAS was also substantial (r = 0.6 – 0.7, large) in young elite soccer players, it was lower than the association found in adults. Therefore, among others factors [9], the age of the athletes seems to influence in the magnitude of the association between field (i.e. UM-TT) and treadmill MAS. Due to the aforementioned substantial differences between field-MAS and laboratory-MAS, it is necessary to be cautious about overplaying the importance of a high correlation.

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Conclusion

Despite the large association between both values, the MAS measured by the UM-TT differs considerably from the MAS measured on a running treadmill in young elite soccer players. The MAS measured by the UM-TT should not be compared directly with the MAS measured on the treadmill in young elite soccer players. Caution should be applied when this field-MAS and laboratory-MAS values are used interchangeably in young soccer training.

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