Ventilatory thresholds in professional female soccer players

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ABSTRACT

This study investigated the ventilatory thresholds (VT1 and VT2) along with the corresponding heart rates, velocities and % of $\dot{V}O2$ max at which these thresholds are reached in professional female soccer players. It also examined positional differences in the aforementioned parameters. Thirty-three professional players from two teams (age range 18–31 years) were recruited. The players underwent maximal exercise testing on the treadmill for the detection of VT1 ($\dot{V}E$ versus $\dot{V}O2$ plot) and VT2 ($\dot{V}E$ versus $\dot{V}CO2$ plot). The test began at a speed of 6km/h and was increased by 2 km/h every 3.15 minutes, with the inclination constant at 1 %. Results indicated that the players had an average $\dot{V}O2$ max of 50.24 ml · kg^{-1}.min^{-1}. VT1 (% max) and VT2 (% max) were shown at 72.87 % and 91.26 % of $\dot{V}O2$ max, respectively. The respective velocities at VT1 and VT2 were indicated at 10.85 km/h and 12.91 km/h, respectively, while the average V$\dot{V}O2$ max was 14.61 km/h. The average heart rates at VT1, VT2 and $\dot{V}O2$ max were 159.33, 185.15 and 192.85 beats per minute, respectively. Furthermore, analysis of variance ANOVA indicated significant differences in velocity at $\dot{V}O2$max. This study provides important normative data regarding the ventilatory thresholds of female soccer players.

Introduction

Considering the transition of female soccer players from non-professional to professional, it is of great importance for strength and conditioning coaches to optimize players' performance. They should, therefore, concentrate not only on the technical and tactical components but also on optimizing physical fitness parameters. Elite female soccer players cover around 10 km during competitive matches, with high-intensity actions accounting for around 1.3 km [1]. In addition, competitive matches have a high reliance on both the aerobic and anaerobic systems and require the players to perform intense accelerations and decelerations that tend to decline towards the end of the match [2]. Thus, sustaining high-intensity intermittent actions for prolonged periods requires high levels of aerobic fitness and anaerobic power [1, 2].

Strength and aerobic capacity are the most frequently assessed physical capacities in male soccer players [3]. Although $\dot{V}O2$ max cannot be used as a determinant of successful soccer performance, it is used to assess aerobic capacity, which is considered an accurate limit of the cardiopulmonary system's ability to transport and utilize oxygen [4]. Despite the limitations that have been demonstrated when $\dot{V}O2$ max values derive from automated metabolic systems [5, 6], $\dot{V}O2$ max values have been reported to range between 55 and 65 ml · kg^{-1}.min^{-1} for elite male soccer players, while values between 47 and 57 ml · kg^{-1}.min^{-1}have been reported for professional female players [1, 7, 8]. $\dot{V}O2$ max has been correlated with various performance parameters such as the total distance covered [9, 10], the number of sprints [11], the number of involvements with the ball [11], the level of work intensity [11], and the competitive level [12] in male soccer players. Furthermore, a longitudinal study that evaluated $\dot{V}O2$ max characteristics in professional female Norwegian soccer players reported that $\dot{V}O2$ max distinguishes players based on competitive levels, but no significant differences in $\dot{V}O2$ max were indicated across positions or age groups [7].

In addition to V̇O2 max, ventilatory threshold one (VT1), ventilatory threshold two (VT2), and peak velocities (Vpeak: peak velocity and VV̇O2 max: the first velocity when V̇O2 max is reached during an incremental exercise test) serve as key physiological measures of aerobic capacity and determinants of optimal training intensity. VT1 is an estimation of the boundary demarcating the moderate to the heavy intensity domain [13] and VT2 is an estimation of the boundary demarcating the heavy to the severe intensity domain [14]. Regarding the first threshold, Owles [15] described that during constant workload tests, there was a critical exercise intensity level unique to each individual above which blood lactate concentration initiates to increase beyond resting values. This critical workload level is generally termed "Lactate Threshold (LT)". This "Owles' Point" [15], i. e. the classical LT [16], is nowadays considered the standard criterion measure for determination of the boundary demarcating the moderate to heavy exercise intensity domain transition [17]. Exercise close to the LT can be sustained for long periods of time (~4 h), and results in no, or modest, accumulation of metabolites [18, 19]. The second threshold traditionally has been associated with the maximal lactate steady state (MLSS). This threshold defines the genuine boundary discriminating between the heavy and severe exercise intensity domains [17, 20]. MLSS represents the upper intensity at which oxygen uptake (VO2) stabilizes without reaching its maximum (V̇O2max) [21], HR does not reach its maximum (HRmax) [21], and blood pH does not change [21] or obtains a stable level close to resting values [22]. Exercise training at this intensity implies metabolic alterations (e. g. increase of blood lactate concentration, muscle inorganic phosphate concentration, hydrogen ion) that are maintained steady over time [18, 19, 23]. Research emphasizes the importance of identifying ventilatory thresholds for the assessment of exercise capacity in soccer players [24, 25].

Evidently, in sports with a heavy reliance on aerobic capacity, such as soccer, performance is limited not only by high levels of V̇O2 max but also by the intensities as determined by the velocities, heart rates, and % V̇O2 max at which ventilatory thresholds are reached [26–29]. While ventilatory thresholds and the percentage of V̇O2 max at ventilatory thresholds have been investigated in various athletic populations [28–30], only one study was identified that examined the ventilatory thresholds and the associated velocities in elite female soccer players [31]. Therefore, this study aimed to determine the ventilatory thresholds (VT1 and VT2) along with the corresponding heart rates, velocities, and percentage of V̇O2 max at which these thresholds are reached in professional female soccer players. A secondary purpose was to examine positional differences in the aforementioned parameters.

Materials and Methods

Thirty-three professional female soccer players (age range 18–31 years, age 23.82 ± 3.86 years, weight 59.84 ± 7.56 kg, height 165.50 ± 6.13 cm) from two teams participating in Division 1 in the Eastern Mediterranean were recruited for the study. The data from the first team were collected when they were champions in the National First Division and participated in the European Women's Champions League. The data for the second team were also obtained during a season in which they won the National Championship.

The players underwent maximal incremental cardiopulmonary exercise testing on the treadmill in addition to the anthropometric measurements. Testing sessions were completed within two days for each team. The tests were conducted at the beginning of the season and after the pre-season preparation period. Both teams had four weeks of preseason preparation, which included 5-training sessions of approximately 90 minutes per week, along with one friendly game each weekend. All the players were advised to avoid heavy physical activities the day before the testing, which was scheduled from 9:00 am to 3:00 pm. They all had previous experience with the testing procedures and participated in the study voluntarily after signing an institutionally approved informed consent. The study was conducted in accordance with the declaration of Helsinki and was approved by the National Committee of Bioethics (CNBC) and the University's ethics board (*blinded*).

Players who reported injuries within the last six months prior to data collection and did not complete the preseason preparation were excluded from the study. Additionally, goalkeepers were not included in the statistical analysis as they had a different preseason preparation.

Anthropometric and body composition analysis

Stature was measured to the nearest 0.1 cm using a wall-mounted stadiometer (The Leicester Height Measure, Tanita, Tokyo, Japan). Body composition was assessed with a leg-to-leg bioelectrical impedance analyzer (BC 418 MA, Tanita, Tokyo, Japan). Prior to the bioelectrical impedance testing, the players were instructed to adhere to standard guidelines, which included fasting for at least four hours, not having intense physical activity the day before the assessment, avoiding drinks with high caffeine content in the previous twelve hours, and emptying their bladder before the test. They were also provided with instructions to follow a specific diet the day before the testing and have a high-carbohydrate meal (60 %-carbohydrates, 300–400 kcal) four hours before testing.

Incremental Cardiopulmonary Exercise Testing

Participants underwent maximal incremental cardiopulmonary testing on a treadmill (HP Cosmos Quasar med, HP-Cosmos Sports and Medical GmbH, Nussdorf-Traunstein, Germany) following the methodology described by previous researchers [32]. Throughout the test, the inclination was kept constant at 1 % [33]. The test began at a speed of 6 km/h and was increased by 2 km/h every 3.15 minutes until the players reached volitional fatigue. A breath-by-breath analysis was conducted using a Cosmed Quark CPET system (Rome, Italy) in constant laboratory conditions (temperature at 22 ± 1 °C; relative humidity at 50 %). Criteria for V̇O2 max included: 1) plateau in V̇O2 (despite an increase in the running speed), 2) respiratory exchange ratio greater than 1.10, and 3) heart rate of + /− 5 % of age-predicted maximum heart rate. At least two out of the three criteria were met, in all cases.

The data were filtered for an average of 10 seconds in order to determine the highest value of $\dot{V}O2$ max. The ventilatory threshold points were identified based on the methodology described by previous investigators [34]. VT1 was considered the lowest workload at which the $\dot{V}_E/\dot{V}O_2$ plot showed a systematic increase without a concomitant increase in the $\dot{V}_E/\dot{V}CO_2$. VT2 was considered the lowest workload at which $\dot{V}_E/\dot{V}O_2$ showed an increase with a concomitant increase in the $\dot{V}_E/\dot{V}CO_2$. Furthermore, VT1 and VT2 were considered as the workloads linked to the first and second non-linear increase in the VE plot. The reported values for the VT1 ($\dot{V}_E$ versus $\dot{V}O_2$ plot) and VT2 ($\dot{V}_E$ versus $\dot{V}CO_2$ plot) were detected by the system automatically but were also manually detected and verified by two expert investigators for accuracy. Despite the widespread use of anaerobic/gas exchange techniques, several investigators have reported relatively low-reliability coefficients ($r^2 = 0.45$) and limitations when using these methods to estimate anaerobic threshold as AT_{LA} and AT_{VE} do not always occur simultaneously [35].

Statistical analysis

Analysis was performed using SPSS, version 28.0, for Windows (SPSS Inc., Chicago, IL, USA). The normality assumption was assessed with the Shapiro-Wilk test ($p > 0.05$). All parameters are presented as the mean and standard deviations, as the normality was confirmed. Positional differences were assessed through a one-way analysis of variance ANOVA. The Bonferroni post hoc analysis was used for pairwise comparisons between group means. The level of significance was set at $p < 0.05$.

Results

Anthropometric and body composition data are presented in ▶ **Table 1**. Based on the cardiorespiratory measurements, the players had an average $\dot{V}O2$ max of 50.24 ± 6.02 ml · kg^{-1}.min^{-1}. $\dot{V}O2$ at VT1 and VT2 were indicated to be 36.47 ± 4.02 and 45.78 ± 5.36 ml · kg^{-1}.min^{-1}, respectively. VT1 (% max) and VT2 (% max) were shown at 72.87 % and 91.26 % of $\dot{V}O2$ max, respectively. %HR max for VT1 and VT2 were demonstrated at 82.51 % and 96 %, respectively. The respective velocities at VT1 and VT2 were indicated at 10.85 km/h and 12.91 km/h, respectively, while the average $V\dot{V}O2$ max was 14.61 km/h. Details on the cardiorespiratory measurements are presented in ▶ **Table 2**.

Regarding the positional differences (▶ **Table 3**), one-way analysis of variance ANOVA indicated significant differences only in $V\dot{V}O2$ max [$F(3,29) = 6.92$, $p = 0.001$]. Post hoc analysis revealed that midfielders reached greater $V\dot{V}O2$ max (15.71 ± 0.76 km/h) compared to defenders and attackers. In addition, based on group comparisons, midfielders and wingers demonstrated greater (but not statistically significant) $\dot{V}O2$ max values than defenders and attackers. Details on positional comparisons are presented in ▶ **Table 3**.

Discussion

To our knowledge, this is one of the first studies to describe the ventilatory thresholds with the associated heart rates, velocities, and percentages of $\dot{V}O2$ max at which these thresholds occur in professional female soccer players. %HR max for VT1 and VT2 were demonstrated at 82.51 % and 96 %, respectively. The respective velocities at VT1 and VT2 were indicated at 10.85 km/h and 12.91 km/h, respectively, while the average $V\dot{V}O2$ max was 14.61 km/h. VT1 (% max) and VT2 (% max) were shown at 72.87 % and 91.26 % of $\dot{V}O2$ max, respectively. Additionally, no positional differences were noted in any of the aforementioned parameters, except for $V\dot{V}O2$ max, where midfielders achieved significantly greater velocities at the end of the incremental cardiorespiratory testing. Based on the cardiorespiratory measurements, the players had an average $\dot{V}O2$ max of 50.24 ml · kg^{-1}.min^{-1}, which is within the values reported for professional female players [1, 7, 8]. Concurrently, it is greater than the average values reported for Chilean soccer players (46.3 ml · kg^{-1}.min^{-1}) [31] but less than those reported for Scandinavian (55.4 ml · kg^{-1}.min^{-1}) [36], Danish (57.6 ml · kg^{-1}.min^{-1}) [37], Australian (51.4 ml ·kg^{-1}.min^{-1}) and English (52.2 ml · kg^{-1}.min^{-1}) [38] elite female soccer players. When comparing $\dot{V}O2$ max values obtained from different studies,

▶ **Table 1** Anthropometric and body composition characteristics (Mean ± SD).

Parameter	Mean ± SD	Minimum	Maximum
	(n = 33)		
Age (years)	23.82 ± 3.86	18	31
Weight (kg)	59.84 ± 7.56	49.2	81.0
Height (cm)	165.50 ± 6.13	152.0	182.0
BMI (Kg.m^{-2})	21.71 ± 1.66	18.7	25.7
Body Fat %	19.25 ± 2.88	13.40	23.90

Note: BMI: Body Mass Index.

▶ **Table 2** Cardiorespiratory results of professional female soccer players (Mean ± SD).

Parameter	Mean ± SD	Minimum	Maximum
	(n = 33)		
Test time (min)	15.69 ± 1.40	13.40	19.10
$\dot{V}O2$ max (ml · kg^{-1}. min^{-1})	50.24 ± 6.02	37.40	63.84
$\dot{V}O2$ at VT1 (ml · kg^{-1}. min^{-1})	36.47 ± 4.02	28.00	42.60
$\dot{V}O2$ at VT2 (ml · kg^{-1}. min^{-1})	45.78 ± 5.36	32.80	54.56
VT1 (% max)	72.87 ± 5.65	60.32	84.52
VT2 (% max)	91.26 ± 5.08	79.95	99.34
HR at VT1 (beats/min)	159.33 ± 20.17	122	198
HR at VT2 (beats/min)	185.15 ± 10.32	159	207
HR max (beats/min)	192.85 ± 8.68	176	209
%HR max (VT1)	82.51 ± 8.75	63.54	94.74
%HR max (VT2)	96.00 ± 3.03	88.46	100
Velocity at VT1 (km/h)	10.85 ± 1.12	8	12
Velocity at VT2 (km/h)	12.91 ± 1.13	12	16
$V\dot{V}O2$ max (km/h)	14.61 ± 1.06	12	16

Note: $\dot{V}O2$: Maximal oxygen uptake; VT1: First ventilatory threshold; VT2: Second ventilatory threshold; HR: Heart rate; $V\dot{V}O2$max: Velocity at $\dot{V}O2$max.

it is important to consider the timing of the tests, as these values can vary throughout the season and following the transition period [8]. In addition, $\dot{V}O2$ max results and ventilatory thresholds should be viewed with caution when the values are obtained from automated metabolic systems as research demonstrated that even under controlled laboratory conditions a physiological significant decrease (drift) is observed in FO2 and FCO2 at the end of maximal exercise testing [5, 6]. Also, it is important to consider which data processing strategy was used (binned time averages versus moving averages or digital filters) when comparing $\dot{V}O2$ max results. Last but not least, regarding the practical significance of $\dot{V}O2$ max, professional players rarely monitor exercise intensity utilizing $\dot{V}O2$. Therefore, it may not be practically useful for prescribing or monitoring exercise programs. Instead, other variables such as the ventilatory thresholds and the related parameters should be quantified in addition to $\dot{V}O2$ max.

Regarding heart rates at VT1, the results of this study were similar to previous studies when male soccer players of top-ranked teams were evaluated [28]. The heart rates of top-ranked players at VT1 were indicated to be 157.49 ± 11.21 [28]. Similarly, the heart rates in this study at VT1 were 159.33 ± 20.17 (82.51 % of HR max). It should be noted that the male and female players were of the same age groups. When it comes to heart rates at VT2, the female soccer players of this study demonstrated greater mean values (185 beats per minute, 96 % of HR max) compared to male players of top-ranked teams (176.18 beats per minute) as well as bottom-ranked teams (170.76 beats per minute) [28]. Additionally, the heart rates of the players in this study at VT1 were similar to those reported for female professional soccer players (mean HR at VT1: 163.2) (aged 25.5 + /− 4 years) from a Chilean first-division soccer club but higher than the values reported for VT2 (177.2 beats per minute) [31]. Considering that the second threshold is associated with MLSS with a corresponding HR close to 90 % of HR max [39], the % of HR max at VT2 in this study (96 % of HR max) is considered high. At the completion of the test, the players of this study reached 99.7 % of age-predicted HR max.

VT1 (% max) and VT2 (% max), in this study, were shown at 72.87 and 91.26 % of VO2 max, while in a similar study, they were reported at 67.9 and 84.2 % of VO2 max, respectively [31]. Considering the higher VO2 max values, in addition to reaching the thresholds at a higher % of VO2 max, it may be assumed that the players of this study exhibited a better aerobic capacity compared to the Chilean female players. This was also confirmed by the authors, who indicated that the lateral and central defenders of the Chilean women's National team have lower aerobic capacity compared to the elite female players of North American and European teams [31]. When comparing our VT1 (% max) and VT2 (% max) values to male soccer players (age 19 + /− 1.6 years) who underwent high-intensity training interventions our results were similar to the post-training values of the different groups. In the particular study, VT1 (% max) and VT2 (% max) were demonstrated at 76.7 % and 91.9 % of $\dot{V}O2$ max [40]. The results of the aforementioned investigation may explain the VT1 and VT2 (% max) findings of this study as the testing was conducted at the beginning of the season and after the pre-season preparation period when the aerobic fitness of the players is expected to be significantly greater compared to baseline values [41]. In addition, the results of this study were in agreement with the thresholds demonstrated by Teixeira and Colleagues (2018) [42], who assessed youth soccer players. The investigators demonstrated VT1 and VT2 at 75.4 and 91.2 %$\dot{V}O2$ peak. On the contrary, lower ventilatory thresholds were demonstrated by several investigators [43, 44]. In a study of Norwegian male soccer players, the thresholds were shown at 64 (VT1) and 79 (VT2) % $\dot{V}O2$ max [43]. The differences in VT1 and VT2 may be attributed to the different methods that the investigators use to identify those thresholds. Considering that the findings of this study were based on the visual inspection of graphs, results might have been different if statistical modelling techniques were used to determine VT1 and VT2.

When it comes to the velocities at different ventilatory thresholds, our results indicated that the average velocities at VT1, VT2 and $\dot{V}O2$ max were 10.85, 12.91, and 14.61 km/h. In a similar study of female players, it was demonstrated that the velocities for VT1 and VT2 were 9.89 and 12.6 km/h, respectively [31]. Furthermore, the velocities indicated in our study were similar to those demonstrated for bottom-ranked male players participating in the Serbian Super League (VT1: 9.57, VT2: 12.53) [28]. On the contrary, players participating in top-ranked teams demonstrated velocities at VT1 and VT2 at 12.83 and 16.41 km/h, respectively [28]. Additionally, the average $V\dot{V}O2$ max in our study was 14.61 km/h, which is in agreement with the results of a longitudinal study on female soccer players [7], which indicated that the $V\dot{V}O2$ max was 14.8 km/h for the national team and 14.4 km/h for first division players. The same study reported $V\dot{V}O2$ max of 13.4, 13.9 and 13.2 km/h for the second division, junior national team and junior players, respectively. Concurrently, the same study [7] reported greater values for $V\dot{V}O2$ max for the midfielders, which is also in agreement with our results, where midfielders achieved significantly greater velocities at the end of the incremental cardiorespiratory testing compared to the rest of the playing positions. The fact that no significant positional differences were indicated in $\dot{V}O2$ max or ventilatory thresholds in our study may be due to the small number of players in each group. Although differences were observed in the mean values (▶ **Table 3**), these were not statistically significant. Furthermore, even though we did not measure running economy, the significant difference in $V\dot{V}O2$ max, despite no differences in gas exchange measurements, may be explained by midfielders having a significantly higher running economy compared to the rest of the positions [45]. It may be worth adding a comparison of these results to the findings of well-controlled studies by Garcia-Tabar and Colleagues [46, 47], who developed and validated equations for the prediction of cardiorespiratory fitness in female soccer players utilizing fixed blood lactate thresholds. The investigators reported that V3mM was 10.1 km/h, corresponding to 91 % HR max and around 76 % Vpeak. Concurrently, they noted that V4mM was 11.0 km/h corresponding to 95 % HR max and around 83 % Vpeak.

In conclusion, while our peak velocity results are in agreement with the literature, our gas exchange computations revealed some discrepancies. The differences in gas exchange computations may be attributed to the different methods used (v-slope, modified V-slope, computerized regression analysis and visual identification) to determine those thresholds. Nevertheless, the results of this study can be of great importance as they can be used for designing training

▶ **Table 3** Positional differences in V̇O2 max, ventilatory thresholds, and relevant velocities (Mean ± SD).

Parameter	n	Mean ± SD	95 % CI Lower-Upper		F-value	Significance (p)
V̇O2max (ml · kg^{-1}.min^{-1})					0.83	0.49
Wingers	8	51.54 ± 7.46	45.31	57.77		
Defenders	12	50.29 ± 5.58	46.75	53.83		
Attackers	6	46.91 ± 6.59	39.99	53.82		
Midfielders	7	51.52 ± 4.47	47.39	55.65		
VT1 (ml · kg^{-1}.min^{-1})					0.85	0.48
Wingers	8	37.30 ± 4.47	33.57	41.04		
Defenders	12	36.52 ± 3.24	34.46	38.57		
Attackers	6	34.21 ± 4.30	29.70	38.72		
Midfielders	7	37.37 ± 4.60	33.12	41.62		
VT2 (ml · kg^{-1}.min^{-1})					1.30	0.29
Wingers	8	47.12 ± 7.07	41.21	53.03		
Defenders	12	45.95 ± 3.31	43.84	48.05		
Attackers	6	42.09 ± 6.93	34.82	49.35		
Midfielders	7	47.12 ± 4.10	43.34	50.91		
VT1 (% max)					0.01	0.99
Wingers	8	72.89 ± 6.79	67.21	78.56		
Defenders	12	72.88 ± 4.97	69.72	76.04		
Attackers	6	73.09 ± 2.71	70.24	75.94		
Midfielders	7	72.65 ± 8.07	65.18	80.11		
VT2 (% max)					0.27	0.85
Wingers	8	91.47 ± 5.74	86.67	96.27		
Defenders	12	91.77 ± 4.86	88.68	94.85		
Attackers	6	89.53 ± 4.49	84.82	94.24		
Midfielders	7	91.64 ± 5.08	89.46	93.06		
Velocity at VT1 (km/h)					0.30	0.83
Wingers	8	11.00 ± 1.07	10.11	11.89		
Defenders	12	11.00 ± 1.04	10.34	11.66		
Attackers	6	10.67 ± 1.03	9.58	11.75		
Midfielders	7	10.57 ± 1.51	9.17	11.97		
Velocity at VT2 (km/h)					0.60	0.62
Wingers	8	13.25 ± 1.49	12.01	14.49		
Defenders	12	12.67 ± 0.99	12.04	13.29		
Attackers	6	12.67 ± 1.03	11.58	13.75		
Midfielders	7	13.14 ± 1.07	12.15	14.13		
vV̇O2max (km/h)					6.91*	0.001
Wingers	8	14.75 ± 1.04	13.88	15.62		
Defenders	12	14.33 ± 0.78	13.84	14.83		
Attackers	6	13.76 ± 0.82	12.81	14.52		
Midfielders	7	15.71 ± 0.76	15.02	16.41		

Note: *$p < 0.05$, V̇O2: Maximal oxygen uptake; VT1: First ventilatory threshold; VT2: Second ventilatory threshold; HR: Heart rate; vV̇O2max: Velocity at V̇O2max.

programs at an appropriate training intensity for professional female soccer players on an individual basis. Considering that it may not be feasible for players to assess their V̇O2 max throughout the season, variables such as heart rates and the velocities at those thresholds can be used instead. Furthermore, this study provides important normative reference values regarding the ventilatory thresholds of female soccer players, while also revealing no positional differences in the thresholds.

Limitations

In addition to the small sample size (especially per playing position), the participants' menstrual cycle was not recorded or considered during the testing. Additionally, V̇O2 max results should be interpreted with caution when obtained from automated metabolic systems, considering the significant drift in FO2 and FCO2 that can occur at the end of maximal exercise testing. Not only V̇O2max might show measurement errors, but also the ventilatory thresholds. Furthermore, our results cannot be generalized to all professional female soccer players. Instead, they could be used on an individual basis or as normative data, as they are based on a specific testing protocol and time of the season.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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