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RESEARCH ARTICLE

# Maximal Oxygen Uptake of Male Professional Soccer Players, 2012-2015, at the End of Four Preseasons Training

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## Abstract:

In professional soccer, a typical preseason in our country lasts four weeks before any official game, it is the time available that clubs have after the players' official vacation to improve their physical preparation. Therefore, the aim of the present study was to analyze the effects of four weeks of training after completion of preparatory training in four preseasons on the aerobic power of soccer players before the start of the competitive season. The main source of energy for the recovery processes during the match is provided by aerobic metabolism, with an average percentage fraction of utilization of the maximum oxygen uptake ($\dot{V}O_2max$) around 70%-80% during the match. An elite player repeats 150 to 250 short, intense actions during a game, several sprints, and 1.9-2.4 km distance at high-intensity exercise indicating that mainly phosphocreatine (PCr) and anaerobic glycolysis usage rates are often high during a game, which is supported by findings of reduced levels of PCr muscle and increases in blood and muscle lactate concentrations several times. Under these conditions, aerobic metabolism has the very important mission of restoring the rapid energy production pathways. A total of 211 soccer athletes (age range, 17-34 years) being 71 professional juniors and 113 professional adults were compared with a control group of 27 non-professionals soccer players. All players performed cardiopulmonary exercise testing in treadmill. The results showed that a large number of soccer players had V̇$O_2$max levels incompatible with the status of professional athletes in this sport after preseason ends. The results among the players were: The player's juniors presented average V̇$O_2$max (56.2 mL.min-1.kg-1) significantly higher ($P < 0.05$) of that the professional players (53.3 mL.min$^{-1}$.kg$^{-1}$) and controls (amateur, 50.4 mL min$^{-1}$.kg$^{-1}$). However, a large number of the adult (67%=76) and juniors (42%=30) professionals players presented values of V̇$O_2$max near to the values covered for the control group. In conclusion, our observation cohort study verified a great number of soccer players, considered of the elite, with values below that it is recommended for players of this competitive level. It seems that preseason training was not enough to achieve compatible V̇$O_2$max levels for most players.

Keywords: Physical fitness, Endurance aerobic Intermittent exercise, Cardiorespiratory assessment.

## Introduction

Soccer is one of the most dynamic games in the world, where players need specialized, strategic tactical, and actual abilities to accomplish a fruitful exhibition, and in the end to win a match [1-2]. The literature reports few studies of monitoring physiological variables of performance during the season phase as well as in the preseason phase [1-2]. Cohort studies in soccer are scarce [2]. Unfortunately, a difficulty encountered is the release and abandonment of the athlete from training for laboratory assessments. In the present study, we were only able to assess the athletes at the end of the four preseason training sessions before the beginning of the competitive season [3]. However, it is known that in many sports the effects of training can also be different in these outcomes (season/preseason). It is widely identified that V̇$O_2$max in humans corresponds to both the functional challenge of the cardiovascular system and the aerobic capacity of the body since V̇$O_2$max is one of the main determinants of performance in human exercise physiology [4].

The V̇$O_2$max aerobic basis of soccer is decisive for the athlete to face interspersed high-intensity activities, including accelerations, running, changes of direction, jumping, lateral step, tackle, and technical skills specific to the game [5] associated with muscle strength, flexibility and sufficient agility [6]. Contemporary soccer when compared to past decades is more intense, faster, and nowadays players cover approximately 30% more distances at high intensity requiring faster recovery [7,55,56]. Thus, one of the most important physiological mechanisms for the soccer player is the ability to recover through the increase in capillarization caused by aerobic training, improving the transport of oxygen to the muscle and the removal of metabolic bi-products produced during the match [8]. Also, increasing mitochondrial muscle density with aerobic training support the aerobic system as a whole [8]. Therefore, as already proven, players with higher VO2max can run at a higher intensity and longer distances before glycogen depletion causes a reduction in intensity [8]. Besids, player $VO_2max$ knowledge is beneficial to coaches in relation to team selection, individual player roles within the team, and for tactical decision-making [9]. Thereby, aerobic conditions for soccer are fundamental and strategic.

Another extremely advantageous effect of aerobic training is the modulation of parasympathetic-sympathetic activity [10]. Restoration during the match itself is another extremely beneficial physiological feature provided by aerobic training. Vagal reactivation is related to better aerobic performance. For a soccer player who needs to get quick transitions, bradycardia is a hemodynamic advantage, as it will represent higher oxygen supplies to the active muscles [10-11].

The combination of the relatively long game duration and the intermittent nature of the low and high-intensity workout dictate that elite soccer players physiologically must have a well-developed aerobic energy system characterized by $VO_2max \geq 60$ $mL.min^{-1}$ $.kg^{-1}$ [2,12] to meet the requirements of general resistance (aerobic endurance) and speed (anaerobic) of the game [2, 11, 12, 13, 14, 15, 16,17].

In current soccer, due to its practical and operational aspects, the use of small reduced field games (SSGs) is massive. Therefore, we observe a tendency to leave out traditional race-based conditional exercises (interval-training and continuous training) during a soccer training session [18]. However, older and newer research [19,20] suggests that SSGs themselves may not be sufficient to promote the same standards of physical demands required during a soccer match, mainly due to the reduced frequency of based metrics in the high-intensity distance of this type of training approach [21,22].

Carroll [23] testified to negative and worrisome comments from an intermittent sport about aerobic training as a waste of time, arguing that it needs to have attributes such as speed, power, agility, coordination, strength, and skills that are characteristic of the game. However, we wonder why cross-country runners incorporate resistance training and speed training into their workout aerobic training regimens? It could be argued that these types of training methods are a waste of time and don't donate energy to distance runners. Nevertheless, do these athletes recognize something that most team sports don't, training every muscle fiber, and energy system. However, and to challenge these false and inconsistent impressions, a study did not find negative correlations for strength, ability to jump, and sprint in soccer players after aerobic training [24].

The aerobic basis of soccer is decisive for the athlete to face interspersed high-intensity activities, including accelerations, running, changes of direction, jumping, lateral step, tackle, and technical skills specific to the game [5,6] associated with muscle strength, flexibility and sufficient agility [5,6]. Therefore, $VO_2max$ is a parameter that needs constant attention and monitoring for the support it gives to these demands [2]. Generally, in our country, the preseason duration is short and lasts only four weeks. They usually play one or two matches a week in competitive period. As the preseason is very short, it is one more reason not to ignore aerobic metabolism during the season [25]. Though it may not seem important, the aerobic energy pathway is essential and indispensable in soccer [5,6]. $VO_2max$ as a highlighter for aerobic capacity is an important variable for this sport because increases physiological performance indicators and physical fitness markers during the match, increasing players' recovery capacity [2,6,12,27]. As contemporary soccer is played at a higher pace and intensity, players have to adapt to the physical requirements of the game.

Professional soccer players have lower relative oxygen uptake during off-season compared to preseason and in-season by a small, but non-significant margin [2]. Overall, there are only small differences in $\dot{V}O_2max$ within categories (playing standard, positions, and seasonal variations). $\dot{V}O_2max$ among male professional players has not improved over the last two decades [2]. It is also important to note that current soccer has had a high scoring and pressure feature on the opponent's ball exit from the pitch of defense to attack, a condition that imposes higher energy expenditure, and consequently, more $\dot{V}O_2$ is required for the attack fulfill this task [2,12,13,14,15]. The participation of aerobic metabolism covers approximately 80%-90% of the energy expenditure of the soccer match, a great justification that in itself deserves the investment in this variable in soccer [24,26,29,47,50]. The 'off the ball's agreement exercise mainly comprises aerobic activity during a match, in addition, direct involvement in the game is offset by the high demand of an anaerobic nature [12,29]. These studies provide some insights into the important physiological parameter that is $\dot{V}O_2max$ for the assistant coaching staff. The aim of the present study was to analyze the effects of four weeks of training in four preseasons on the aerobic power ($\dot{V}O_2max$) of soccer players before beginning the competitive season.

## Materials and methods

### *Compliance with ethical standards*

All the participants were informed of the procedures and the purpose of the study, and their written informed consent was obtained. The study was approved by the requirements of the Institution Ethics Committee of Medical School of São Paulo University (case number # 1251/11). The participants were permitted to withdraw at any time for any reason. Further, this study was conducted to conform to the Declaration of Helsinki.

### *Study design and participants*

The present study is a cohort study on data retrospectively and observational collected Brazilian male soccer players on $\dot{V}O_2max$ was monitored at the end of each preseason in four seasons (2012-2015). Keepers did not participate in this study, as they perform 90% less high-intensity actions (over 19.8 km/h) than the rest of the players [30]. The study's sample was selected by convenience. Data from 211 male soccer players (184 professional and 29 non-professional) with age (17-34y) formed the basis for this investigation (Table 1). The study did not have any intervention in the training of athletes. The predominant school level of the players was 90% (n=102) complete high-school, 8% (n=9) unfinished, and 2% (n=2) had finished higher education (college). All measures were conducted 4 weeks immediately after ended into preseason training before starting 2012, 2013, 2014, and 2015 seasons at the Movement Studies Laboratory at the Institute of Orthopedics and Traumatology (FIFA Medical Center of Excellence), Hospital das Clínicas, Faculty of Medicine, University of São Paulo. These players had in average of four for 10 years of experience with the high-level soccer. The athletes that took part in this study were free from cardiovascular, pulmonary, orthopedic, and metabolic diseases. They participated in organized training 10.0 ± 1.0 hour per week, with one or two matches a week, on average. All participants were asked to abstain from any high-intensity physical activity 24h prior to the test session. Furthermore, they were asked to refrain from consuming caffeine and nutritional supplements on the assessment day. Team squads were tested on separate, but successive days. Season preparing time for major competitions in our country lasts one month. The group of soccer players who participated in the study (42 central-defenders, 45 fullbacks, 60 midfielders and 64 strikers, neither goalkeepers), 27 were non-professionals (G1), 71 were professional junior's (G2) and 113 were professionals adult's (G3). The control group practiced soccer non-professional two times per week and did not make specific training for the soccer play. To participate in this study, professionals athletes had to meet the following inclusion criteria: (i) actively participate in sports competitions; (ii) be formally registered with a local, regional or national sports federation; (iii) have training and competition as their main activity (way of life), (iv) focus of personal interest, dedicating several hours in all or most days to these activities, generally exceeding the time allocated for other types of professional or leisure activities; (v) no locomotor limitation capable of affecting performance in the CPX exercise test, and (vi) being 17 years of age or older [31]. The juniors and professionals player's were all of high-level, on average trained five times per week with ten hours of weekly training and all the players belonged to the teams that participated of the main competitions performed by the Sao Paulo Soccer Federation of the Sao Paulo State/Brazil.

### *Anthropometric assessment*

Mass was measured with the subjects wearing light clothing and no shoes to the nearest 0.05 kg by digital weighing scale (Welmy®, 200/5, Santa Barbara d´ Oeste, São Paulo, Brazil). Height was measured without shoes to the nearest 0.1 cm by rigid stadiometer (Welmy®, 200/5, Santa Barbara d´ Oeste, São Paulo, Brazil). Body mass index (BMI) was derived as weight/height$^2$. For body fat percentage (% FAT), we use the formula [body Fat = (1.2 × BMI) + (0.23 × age) - (10.8 × 1) - 5.4], is inexpensive, easy, and convenient for coaches and athletes to rate players during season [32].

### *The maximal aerobic power assessment*

Two hours after eating breakfast the participants performed an incremental test to exhaustion. Each athlete underwent physician-supervised standard incremental CPX testing conducted on a motor-driven treadmill (h/p/cosmos®, pulsar, Nussdorf-Traunstein, South of Germany). On the testing day, the laboratory room temperature was between 20–23°C, and the relative humidity was approximately 60%. The treadmill grade was constant at 1.15° (2% slope) to replicate outdoor over-ground running on grass, as running on grass corresponds to an inclination of approximately 2% under strong verbal encouragement to promote the maximal effort [33]. All participants were familiar with treadmill running. Tests were terminated upon volitional exhaustion of the participant or the participant's inability to maintain the target treadmill speed. In this protocol, the players remained at rest for two minutes, and then warmed up for three minutes at treadmill speeds of 4.8, 6 and 7.2 $km.h^{-1}$ (one minute each). The test began at 8.4 $km.h^{-1}$ and the treadmill speed increased by 1.2 $km.h^{-1}$ every two minutes. The incremental protocol performed by athletes was chosen to obtain time to exhaustion around 8-17 minutes [34]. The subjective perception of the effort was verified in each test period using Borg's 15-point linear scale [35]. The players were instructed to run until voluntary exhaustion was reached and were given strong verbal encouragement throughout the test to elicit their best performance [36].

Ventilation, oxygen uptake, production of carbon dioxide and respiratory exchange ratio (RER) were continuously monitored by means of a breath-by-breath metabolic system (MedGraphics® CPX/D, St. Paul, Minnesota, USA) and the data was analyzed with BreezeSuite® 6.4.1 cardiorespiratory diagnostic software. This metabolic cart measures expired air flow by means of a pneumotach connected to the mouthpiece. A sample line was connected to the pneumotach, from which air was continuously pumped to oxygen ($O_2$) and carbon dioxide ($CO_2$) gas analyzers. Prior to testing, the pneumotach was calibrated with ten samples from a 3-liter calibration syringe (Hans Rudolph®, 5530, Kansas City, MO, USA). The gas analyzers were also calibrated before each test in relation to room air and medically – certified calibration gases (11.9% and 20.9% $O_2$ and 5.12% $CO_2$, respectively), balanced with nitrogen ($N_2$). During the test, the players had a rubber mouthpiece, and nose clip. The loss of verbal communication with the soccer players during the test was overcome with prearranged hand signals. Heart rate (HR) was continuously recorded during exercise by means of electrocardiography (HeartWare® Instruments, 6.4, Belo Horizonte, BRA). The physiological criteria for approval of the $\dot{V}O_2max$ was assessed when the following criteria were satisfied: (i) leveling off (plateau) on the $\dot{V}O_2$ curve with an increase of ≤ 2.1 $mL.min^{-1}.kg^{-1}$ between the penultimate and the last stage reached by the final test [37], (ii) RER > 1.10 [38], (iii) the HR during the last minute exceeded 95% of the expected maximal HR predicted maximal [208 – (age * 0.7)] [39], (iv) more than 18 in the scale of Borg [40], and (v) the players were no longer able to continue the running despite verbal encouragement. All the participants evaluated satisfied at least three criteria. Additionally, information from the $\dot{V}O_2max$ tests was time-averaged at 30-s intervals.

### *Questionnaire*

Questionnaires are a very convenient way of collecting useful comparable data from a large number of individuals. However, questionnaires can only produce valid and meaningful results if the questions are clear and precise and if they are asked consistently across all respondents. In this questionnaire applied to the players, we opted for multiple-choice closed questions (Table 5). A closed question is one where the possible answers are defined in advance and so the respondent is limited to one of the pre-coded responses given. To understand the type of training that soccer players received, the physical qualities, and the meaning were explained individually and they answered: yes=1, not=2, or sometimes=3. The response of the participants was spontaneous. The frequency of each answer was transformed into numbers, which made it possible to convert into a percentage. To avoid bias of information, every soccer player was interviewed alone in the room. The trainers did not participate in the questionnaire with the athlete present. The participation of the trainer would not isolate the athlete, and it could intimidate him, causing a bias in the response. The participation of trainers was only in describing the training modalities for the construction of the questionnaire.

### *Statistical analysis*

Outcomes are reported as mean ± standard deviation (SD) and the minimum and maximum variations. The morphological characteristics are presents for age, weight, height, body mass index (BMI), and fat percentage. For comparison of the dependent variable $VO_2max$ between the non-professionals (amateur) adult's soccer players (group 1, control), professionals adult's soccer players (group 2, elite) and professionals junior's players (group 3, elite) one-way analysis of variance (ANOVA) was used and in case of significant F ratio was observed among the means, Tukey post-hoc method was used to determine the location of the differences. Statistical significance was set at $P < 0.05$ [41]. To measure the magnitude of the effect (Effect Size=ES) of the supplementation it enters the pairs of the groups, was calculated measure g of Hedges [42]. We consider d=0.2 a "small" effect, d=0.5 "intermediate" and d=0.8 a "large" effect [43]. Considering the ES between the G1 and G2, and accepting the assumption of normality, we can describe d in terms of expected proportion of individuals in the G2 that exceed the typical value of G1. This value can be easily derived through table of quantiles of standard normal distribution that can be found in many biostatistics books. The percentages of soccer players in the three groups (nonprofessionals, juniors and adults soccer players) with $VO_2max$ below 55 $mL.min^{-1}.kg^{-1}$; below 50 $mL.min^{-1}.kg^{-1}$ and; at least 60 $mL.min^{-1}.kg^{-1}$ was compared by Chi-square homogeneity test. An alpha level of 0.05 was used for statistical significance. All statistical analysis was performed using Sigma Stat (version 3.5, Systat Software, Inc, Point Richmond, CA, USA).

## Results

The present study was carried out at the end of preseason training in four seasons (2012-2015). Descriptive statistics of age, weight, height, BMI and fat percentage were demonstrated in Table 1.

Table 1. Morphological characteristics of nonprofessional (amateur) adult's soccer players (G1: n = 27), professionals adult's soccer players (G2: n = 113) and professional's junior's soccer players (G3: n = 71)

| Groups | Age (years) | Mass (kg) | Height (cm) | BMI ($kg/m^{-2}$) | FAT (%) |
|---|---|---|---|---|---|
| G1 (Nonprofessionals Adult's soccer players) | 22.8 ± 3.2 (19 – 31) | 74.1 ± 8.3 (60 – 94) | 177.4 ± 6.4 (164 – 188) | 23.5 ± 3.2 (22.3-26.6) | 17.2±2.4 (16.1-22.8) |
| G2 (1st. Division/ Professionals Adult's soccer players) | 23.4 ± 4.1 (18 – 34) | 74.5 ± 8.6 (58 – 97) | 178.9 ± 7.2 (162 – 198) | 23.3 ± 2.6 (21.0- 24.7) | 17.1±2.5 (11.0-21.2) |
| G3 (1st. Division/ Professionals Junior's soccer players) | 18.3 ± 0.9 (17 – 20) | 70.4 ± 5.9 (58 – 84) | 177.3 ± 5.7 (164 – 187) | 22.4 ± 1.6 (20.0 – 24) | 14.8±1.8 (10.5- 17.2) |

BMI, body mass index

Table 2 presents the mean of $\dot{V}O_2max$ of the players in each group. We can see by Tables 2 and 3 that the mean of $\dot{V}O_2max$ of the player's juniors (56.2 ± 4.0 $mL.min^{-1}.kg^{-1}$) was significantly greater than the mean of the professional players (53.3 ± 3.9 $mL.min^{-1}.kg^{-1}$; $P < 0.001$) and non – professional players (50.4 ± 4.2 $mL.min^{-1}.kg^{-1}$; $P < 0.01$).

Table 2. ANOVA for comparison of mean of maximum oxygen uptake ($\dot{V}O_2max$) of nonprofessional's (amateur) adult's soccer players (G1), professional's adult's soccer players (G2) and professional's junior's soccer players (G3)

| Groups | n | $\dot{V}O_2max$ $mL \cdot min^{-1} \cdot kg^{-1}$ (mean ± SD) | F | P |
|---|---|---|---|---|
| G1 (Nonprofessionals Adult's soccer players) | 27 | $50.4 \pm 4.2^{b,c}$ | 23.435 | < 0.001 |
| G2 (1th Division Professionals Adult's soccer players) | 113 | $53.3 \pm 3.9^{a,c}$ | | |
| G3 (1th Division Professionals Junior's soccer players) | 71 | $56.2 \pm 4.0^{a,b}$ | | |

Tukey Post-hoc tests. Significant if $P \leq 0.05$. a: different from Nonprofessional's adult's soccer group; b: different from Professional's adult's soccer group; c: different from Professional's Junior's soccer group

Table 3. Tukey's Post-hoc test and Effect Size for comparison of mean of maximum oxygen uptake ($\dot{V}O_2max$) of nonprofessional (amateur) adult's soccer players (G1), professional's adult's soccer players (G2) and professional's junior's soccer players (G3)

| Comparisons | | | Effect Size (Hedges' g) | P (Tukey) |
|---|---|---|---|---|
| G1 (Nonprofessionals Adult's soccer players) | *vs.* | G2 (1th Division/ Professionals) | 0.806 | 0.004 |
| G1 (Nonprofessionals Adult's soccer players) | *vs.* | G3 (1th Division/Junior's) | 1.485 | < 0.001 |
| G2 (1th Division/ Professionals) | *vs.* | G3 (1th Division/ Junior's) | 0.731 | < 0.001 |

Besides, the mean of $\dot{V}O_2max$ of the professional players was significantly greater ($P = 0.004$) than the group of non-professional players (Figure 1).

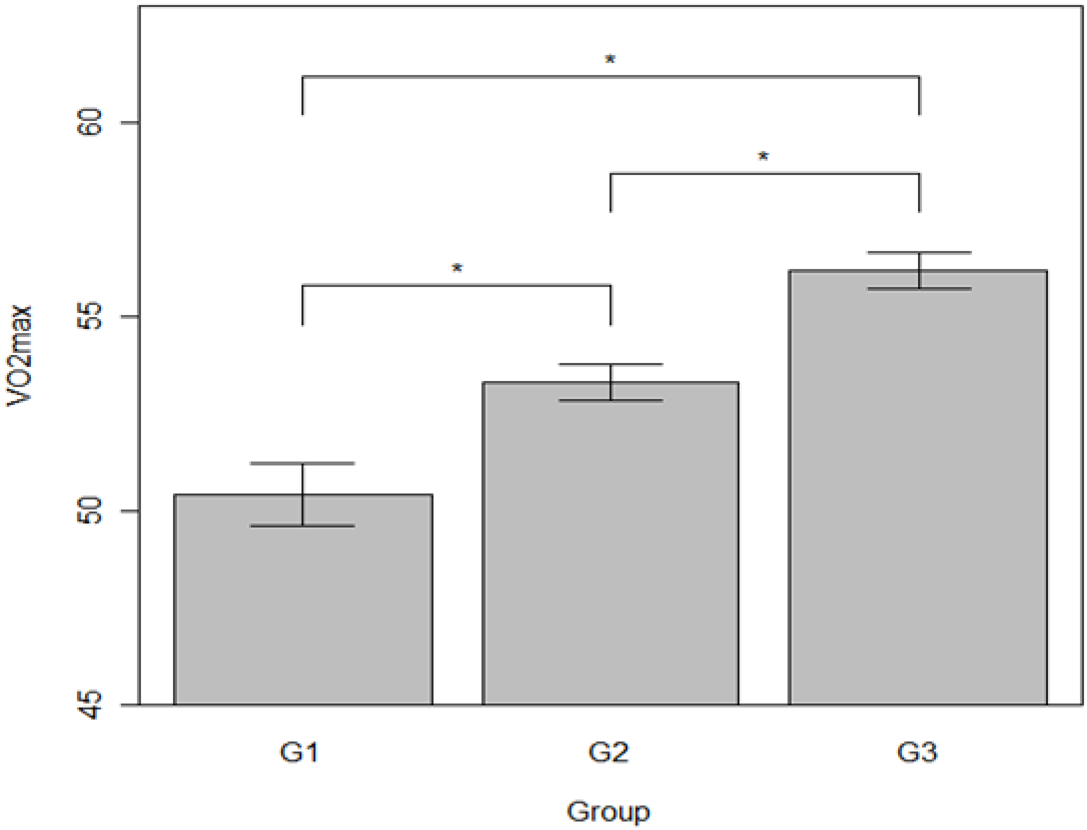


Figure 1. Mean (± SD) of maximal oxygen uptake ($VO_2max$, mL.min$^{-1}$.kg$^{-1}$) of nonprofessional's (amateur) adult's soccer players (G1), professional's adult's soccer players (G2) and professional's junior's soccer players (G3). (*) indicate significant difference.

The Hedges'd (effect size) between G1 and G2 was d=0.806 (larger effect). Accepting the assumption of normality, this means that 79% of the players of the G2 will exceed the average VO2max of the G1. For the other values of effect size, d=1.485 and d=0.731 implies a proportion of 93% and 77%, respectively. Table 4 presents the number and percentage of soccer players in the three groups with $VO_2max$ below 50 mL.min$^{-1}$.kg$^{-1}$; below 55 mL.min$^{-1}$.kg$^{-1}$ and; at least 60 mL.min$^{-1}$.kg$^{-1}$.

Table 4. Number and percentage of soccer players in the three groups (nonprofessionals [amateur], juniors and adults soccer players) with $VO_2max$ below 55 mL.min-1.kg-1; below 50 mL.min$^{-1}$.kg$^{-1}$ and; at least 60 mL.min$^{-1}$.kg$^{-1}$

| Variable | G1 (nonprofessional's) (n=27) | G2 (Professional's adults) (n=113) | G3 (Professional's junior's) (n=71) |
|---|---|---|---|
| $\dot{V}O_2max$ < 55 mL·min$^{-1}$·kg$^{-1}$ | n=24<br>89% $^{b,c}$ | n=76<br>67% $^{a,c}$ | n=30<br>42% $^{a,b}$ |
| $\dot{V}O_2max$ < 50 mL·min$^{-1}$·kg$^{-1}$ | n=13<br>48% $^{b,c}$ | n=18<br>16% $^{a,c}$ | n=3<br>4% $^{a,b}$ |
| $\dot{V}O_2max$ > 60 mL·min$^{-1}$·kg$^{-1}$ | n=1<br>4% | n=2<br>3% $^{c}$ | n=12<br>17% $^{b}$ |

Chi-square homogeneity test for equality of the percentages. Significant if $P \leq 0.05$. a: different from Nonprofessionals (amateur) group; b: different from Professionals group; c: different from Juniors group.

Notice that the percentage of players with VO2max below 50 mL.min$^{-1}$.kg$^{-1}$ in G1 (48%) is greater than in G2 (16%) and G3 (4%). In addition, the percentage of G2 is greater than the G3. The same occurs for the percentage of players with $\dot{V}O_2max$ below 50 mL.min$^{-1}$.kg$^{-1}$, where the percentages of G1, G2, and G3 are 89%, 67%, and 42%, respectively. For the percentage of players with $\dot{V}O_2max$ at least 60 mL.min$^{-1}$.kg$^{-1}$, the only significant difference was between G2 (3%) and G3 (17%) (Figure 2).

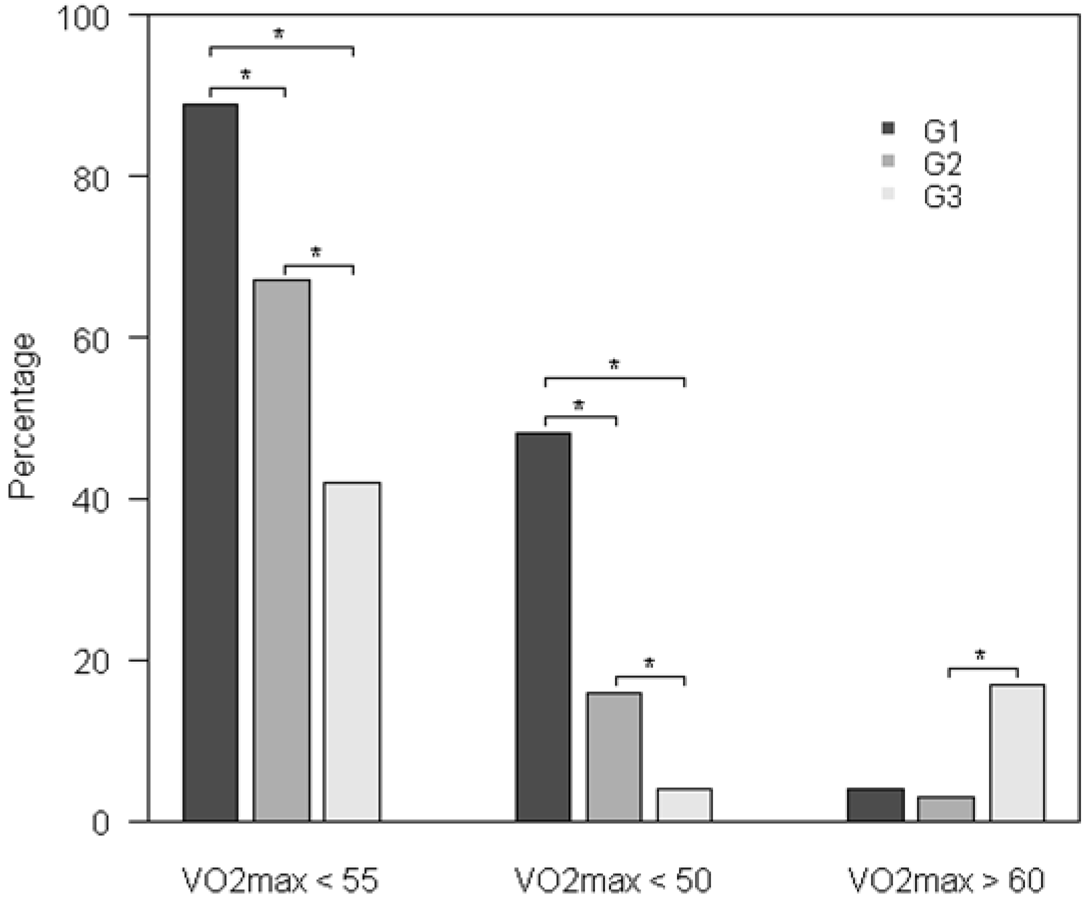


Figure 2. Percentage of soccer players in the three groups (nonprofessionals [amateur], juniors and adults soccer players) with $VO_2max$ below 55 $mL.min^{-1}.kg^{-1}$; below 50 $mL.min^{-1}.kg^{-1}$ and; at least 60 $mL.min^{-1}.kg^{-1}$. (*) indicate significant difference

However, what draws consideration is the large number (n = 56) of adult professional players representing 67% of the sample with $VO_2max$ below 55 $mL.min^{-1}.kg^{-1}$ (Table 4). The questionnaire in Table 5 highlights the perception of the type of training transformed into a relative percentage for each physical quality answered by the athletes. As shown in Table 5, the discrepancy is notorious, the disproportion of aerobic stimuli reported by the players when answering the questionnaire. The 5% stimulus rate is not compatible with the soccer request. The almost absence of aerobic training (question I=QI) showed a consensus of 95% among the players (Table 5).

Table 5. Questionnaire applied to junior players and professional adults about the characteristics of the physical qualities trained during the sessions by the trainers (season and preseason)

| Physical Qualities | Yes=1 (%) | Not=2 (%) | Sometimes=3 (%) |
|---|---|---|---|
| (QA) Agility exercises | 100 (N=184) | 0 | 0 |
| (QB) Velocity (sprint training) | 100 (N=184) | 0 | 0 |
| (QC) Small-sided games [reduced pitch] (3 x 3; 4 x 4; 5 x 5; 6 x 6); 3-4 times weekly | 90 (N=166) | 5 (N=9) | 5 (N=9) |
| (QD) Core and functional exercises | 80 (N=147) | 15 (N=28) | 5 (N=9) |
| (QE) Resistance exercises (weight training) | 70 (N=129) | 20 (N=37) | 10 (N=18) |
| (QF) Balance exercises | 30 (N=55) | 65 (N=120) | 5 (N=9) |
| (QG) Flexibility exercises | 40 (N=174) | 40 (N=174) | 20 (N=37) |
| (QH) Circuit training exercises | 60 (N=110) | 30 (N=55) | 10 (N=18) |
| (QI) Cardiorespiratory endurance (continuous training, long interval-training, 3x3 min or 4x4 min) | 5 (N=9) | 95 (N=175) | 0 |

Note: The dispersion found regarding the variables operated by the trainers during the training sessions by the players is very diverse. N= number of players who answered the questions (Q=question)

## Discussion

The most important communication from the present study supports the need for aerobic physical conditioning, although it can be refuted and controversy may still exist in the minds of several soccer professionals. The aerobic energy system in soccer is highly rated during a game, having the mission of renewing the energy from the anaerobic metabolisms as quickly as possible, which is also high during moments of the game. However, given the evidence in the literature, it will be difficult to eliminate aerobic training from soccer [24,25,26,46]. That's what we'll discuss in this article. Therefore, based on the results of the present study, and compared with results from other studies in the literature [2,12,14,44,45]. Therefore, the hypothesis of lower aerobic development of athletes at the end of the preseason must be accepted with caution [2,47]. Thus, the focus of attention in this study was the lower aerobic capacity after the end of the players' training in the preseason before starting the competitive season.

The results of the present study showed many professional soccer players with insufficient $VO_2max$ values when compared to the control group. Some misconceptions exist about how best aerobic conditions for soccer players. However, although old, $VO_2max$ is still one of the parameters stratified of the maximal aerobic capacity to classify the level of functional performance of the soccer player [2,14,25,47]. In this discussion, we have grounded the importance of anaerobic issues in the context of soccer and compared our results. Table 5 shows the reality and portrait of training used in soccer players currently, at least in our country. As can be seen, aerobic metabolism was privileged in only 5% of all activities carried out over the four preseasons followed (Table 5).

In our country, one of the current justifications of physical trainers is that since soccer is a sport of intermittent activity with intense short workout, longer activities would not contemplate the characteristics of this sport and aerobic exercise could slow athletes down [23]. It seems that this kind of thinking is not consistent with the results of some classic studies [2,24,26,44,47,49,50]. One of the most consistent studies with soccer players showed expressive physiological results of long interval training, with a stimulus of 4 minutes, where there were significant increases in $\dot{V}O_2max$ of 11%, anaerobic threshold of 16%, and running economy of 6.7% [26]. Besides, the distance covered on the field increased by 20%, the number of sprints by 100%, and the engagement with the ball during the match by 24% [26]. Another important aspect was the increase in cardiovascular capacity in submaximal exercise, which increased from 82% to 86% [26]. Therefore, long-term interval training increased players' central and peripheral capacity [26,45]. Besides all the improvements brought about longer interval training, this training regimen could be expected to increase $\dot{V}O_2max$ by 0.5% per training session which is a very cost-effective way [26]. In this same line of thought, another study showed that longer exercises applied to soccer players did not slow them down [24]. Undoubtedly the $\dot{V}O_2max$ is a very important variable of match performance of soccer players [2,26,45, 46]. Thus, we can see that the soccer players in the present study were not provided with enough aerobic load to increase the $\dot{V}O_2max$ at the end of the preseason, and probably following this scenario, not even during the competitive season. Earlier studies and older already concluded that 60-65 $mL.min^{-1}.kg^{-1}$ was enough to play internationally in men's soccer [46]. A decade later, Reilly et al. [12] stated, and more current than ever, that mean $\dot{V}O_2max$ values greater than 60 $mL.min^{-1}.kg^{-1}$ in elite teams, and not verified as in the players in the present study, suggest the existence of a threshold below which an individual player is unlikely to be physically successful in contemporary first-class soccer with scores below this index. Using the timeline, another study showed that the aerobic level in soccer when well developed is maintained properly during the season [2,47]. In turn, at different times, another study found values of 65.5 and 66.4 $mL.min^{-1}.kg^{-1}$ in high-level Spanish players [47].

Clark et al. [44] monitoring a three-season cohort of soccer players found in variations in aerobic power in a significant homogeneous and well-trained population with $\dot{V}O_2max$ of 61.5 $mL.min^{-1}.kg^{-1}$. In another 23-year cohort study, perhaps the best conducted to date, compared and showed that $\dot{V}O_2max$ between first- and second-division and junior players dropped only between 1.6% and 2.1% in preseason and again in next season. The authors concluded that $\dot{V}O_2max$ between 62 and 64 $mL.min^{-1}.kg^{-1}$ is the most adequate to compensate for the aerobic needs of male soccer [2]. Interestingly, Casajus [47] and Magal et al. [48] observed a higher $\dot{V}O_2max$ towards the end of the season. On the other hand, meanwhile, Heller et al. [49] and Metaxas et al. [50] demonstrated better $\dot{V}O_2max$ at the end of preseason or early next season. In accordance with of Stolen et al. [14], a 75 kg professional soccer player should have a $\dot{V}O_2max$ of 70 $mL.min^{-1}.kg^{-1}$ taking into account the duration and intensity of the game. In the present study, the mean $\dot{V}O_2max$ values for junior and adult players after training at the end of the preseason when compared to the studies cited above were between 14% and 20% below what is recommended for well-trained soccer athletes in a stage so close to the start of the competitive season [2,12,44,45,47]. However, it cannot be ignored that our players achieved results that are similar to those reported for 2nd division players [71], while it would be expected that their results will be closer to those reported in studies performed on 1st division players, which reported average values of above 60 $mL.min^{-1}.kg^{-1}$ [29,47]

In another study [51] comparing the V̇O2max in the preseason between younger players (17-22 years) and older players 27-36 years, and similar to the present study, found no significant difference between the values 62.7 ± 6.1 vs. 63.2 ± 6.2 $mL.min^{-1}.kg^{-1}$, respectively. When we compare these values with those of the present study in the same phase, that is, preseason, they were significantly higher by 10% and 16%, respectively, indicating that the aerobic capacity was not adequately developed. Therefore, based on this fact, it is hypothetically possible to imagine that during the season the aerobic training of the players in the present study was not enough and in the preseason it did not improve adequately, since many athletes, especially professional adults, showed values below 50 $mL.min^{-1}.kg^{-1}$ (Table 4). It is important to emphasize that the lower aerobic performance of the players verified in the preseason, without proper correction, can result in a competitive phase disadvantage in the early stages as well as in the final stages [25]. The literature has shown that at the current competitive level, $\dot{V}O_2max$ in elite, international, and professional soccer players ranges from 59.2 to 63.2, 59.2 to 61.5, and 58.2 to 62.2 $mL.min^{-1}.kg^{-1}$, respectively [12,14,52] or even higher [2,44,47,51]. This study nullifies any justification for a $\dot{V}O_2max$ as low as found in our laboratory. Notably, $\dot{V}O_2max$ is an index of the body's efficiency in work production [12,17,47]. One study showed the denial of aerobic training after a preseason of five weeks and confirms the information transmitted by the players when answering the questionnaire presented in Table 5 [53].

Another extremely important aspect for soccer players is that greater aerobic fitness is associated with a reduced risk of injuries and illnesses during the preseason and competitive season [54]. Furthermore, the concept that athletes with greater aerobic power increase the body's ability to recover from intermittent anaerobic effort such as in soccer is well known [55,56]. Increasing the aerobic level improves the physiological ability to increase post-exercise excessive oxygen consumption (EPOC), $\dot{V}O_2max$, lactate buffer (HCO3), and improves phosphocreatine (PCr) storage replacement [26,55,56].

It is important to note that in the presence of high $\dot{V}O_2max$, well-trained soccer athletes consume more oxygen during stimulation than athletes with low $\dot{V}O_2max$, and therefore poorly trained. Consequently, high $\dot{V}O_2$ early in the recovery phase of high-intensity workout result in the likelihood of faster EPOC. Therefore, faster EPOC results in the ability to reset ATP/PCr energy sooner, and therefore the athlete returns to play at a higher and more powerful level [55,56]. Short-duration sprints in soccer match are known to be performed under 10 seconds, interspersed with brief recoveries of less than 60 seconds for most team sports [57]. Therefore, the faster aerobic metabolism regains the athlete's fast metabolic pathway, even partially, is a huge acquired advantage [55,58,59,60,61]. Higher $\dot{V}O_2max$ correlates with faster pulmonary oxygen kinetics and more benefits to the athlete's recovery process [61]. Therefore, a fast pulmonary kinetics of $O_2$ attenuates disturbances in intramuscular metabolic homeostasis due to greater aerobic contribution. Slow $O_2$ kinetics has been a serious problem, as the greater amplitude of the slow $\dot{V}O_2$ component is critical to performance [74,75,76]. During recovery, the period is where many important functions take place [55,56]. Theoretically, an increase in aerobic fitness could improve recovery from anaerobic performance, either by supplementing anaerobic energy during exercise or by providing aerobically derived energy at a faster rate during the recovery period [55,56]. The fatigue is temporary during the match. A good aerobic capacity will allow the athlete to recover, even if only partially, during less intense periods of the match. Therefore, improving the aerobic peripheral component reflects the muscle's ability to utilize the oxygen provided, which depends on the properties of mitochondria, oxidative enzymes and capillary density in the muscles. In addition, any improvements that aid transport to or from the muscle, such as increased blood flow, can increase the removal of $H^+$ lactate and heat [55]. Improved aerobic fitness aids in greater concentration and can help players make fewer technical and tactical errors. Players with higher $\dot{V}O_2max$, after repeated high intensity exercise, remove more lactate, quickly regenerate phosphocreatine stores, and improve mental concentration [55]. To play soccer well physically, the player should continue aerobic training throughout the year in the off-season as well as during the season. Based on several authors, we have reason to believe that throughout the 4 seasons was not given in the development of this notably important metabolic variable for soccer players [26,45].

Another aspect that stands out is that injury rates are also reduced with the association of greater aerobic fitness [62]. Therefore, this study has the mission of alerting physical trainers and coaches about the aerobic level as one of the most important components of the general physical conditioning of soccer, which not only improves athletic preparation but also protects players from injuries [62].

Another important point observed in the present study and shown in Table 5, there is a high percentage of small-sided games (SSGs) and reduced aerobic training. One of the justifications is that this specific training model improves the aerobic level of athletes in conjunction with the technical part of the game. Contrary to this thought, some researchers [19,20] have shown in adults and young players that this training modality does not fully meet the adequate energy expenditure for the cardiorespiratory and metabolic compensation of athletes. It is believed that the specificity of training with a ball in a reduced pitch (SSGs), with variations of players in groups, e.g. 3x3, 4x4, 5x5, and 6x6 drills develops the aerobic metabolism of athletes. However, not all athletes reach the necessary intensity of a soccer match in this model. The difficulty encountered is the control of intensity that is often not maintained by the athlete with the ball. The possible difference found in our results may be linked to the control of the athletes' aerobic training sessions, that is, individual vs. group [63]. This author highlights the importance of controlling aerobic training through individualization.

Recently, the study by Massamba et al. [20] compared high-intensity interval training (HIIT) with ball exercises in a reduced pitch (SSG). The physiological response was more efficient in the athletes who performed the HIIT than the three SSG in various field sizes. Each SSG was performed with 5 players per team, for 4 × 4 minutes interspersed with one minute of passive recovery between them. The long HIIT also followed a 4 × 4-minute protocol with individually defined running speed. For each exercise modality, the time spent was above 90% of the calculated HRmax, and the technical actions were quantified during the SSG by video analysis. HRmax was similar between SSG but was 24% to 37% lower than during HIIT indicating inadequate acute aerobic workout suggesting a lower potential for chronic aerobic adaptations compared to long HIIT. Although older, the results obtained 19 years ago by Helgerud et al. [26] confirm that individualized interval training is more efficient and similar to the results found by Massamba et al. [20] for improvements in aerobic level. As perceived in the current study this condition was not explored (Table 5).

Another study with preseason soccer players, analyzing 504 individual training sessions of SSG, showed that players spent almost two-thirds of their training time at low intensities [19]. However, only a third of the time was spent in high intensity (> 90% of maximum HR) in aerobic conditioning [19]. Soccer coaches must select the appropriate training program according to the training aim and expected results. Training in a reduced pitch has its importance, a smaller pitch seems to be more suitable for technical issues, such as dribbling, acelerating or short passes, and according to the aim of each training, coaches can use larger or smaller pitches [64].

One study compared SSGs in domestic, men's, national and international games and found that although SSGs simulate the general movement patterns of soccer competition, they do not simulate the high-intensity repeat sprint demands of competition, especially at the prolonged speed, as the field of soccer is large, and the scale of the reduced pitch is small [65].

More recently, Clemente et al. [77] verifying the performance of the SSGs format of 5 x 5 players showed a drop in performance in the physical demand of the athletes. They also checked heart rate variability after the last exercise set using this format. Therefore, if the aim is to improve athletic fitness, this training modality must be rethought. It appears that the results of the present study are in agreement with those found by the group by Clemente et al. [77] which guides coaches to seek other strategies and avoid declining athletes' performance throughout the season. Therefore, complementary physical training is needed for these greater demands for displacements. Thus, aerobic training enhances the ability to recover quickly from strenuous activity as well as improve the capability to sustain exercise and must be valued in soccer [26,55,56]. In contrast, the excessive use of SSGs training in the pitch does not simulate the athlete's different displacement formats during the match [65].

Although the SSG is of relative importance, games are not the best workout for fitness, aerobic capacity is extremely important. Aerobic endurance improves distance covered, number of sprints, and involvements with the ball [26]. Top-class soccer players perform more high-intensity runs than lesser peers. Aerobic demand for soccer is high. In contrast, the anaerobic lactate component is less than what many believe [72]. Due to the high-intensity intermittent effort and short duration actions with insufficient recovery, soccer can be better classified as an alactic-aerobic sport with a lot of reliance on aerobics [55,56]. Aerobic capacity fuels the ability to perform repeated high-intensity efforts when the rest interval between efforts is insufficient for complete recovery [45,55]. Muscle pumping is more consistent during the run than during the game; subsequent, heart-filling and stroke volume in running through continuous and interval running is higher [78]. The stroke volume is crucial for a better adaptation of the heart; therefore, running can stimulate the heart better than SSGs.

Arslan et al. [63] believe that the mix of training with SSGs and HIIT together seems to be an interesting alternative in soccer. These results confirmed that SSGs training might be a more effective training regime to improve technical ability and agility with greater enjoyment, motor displacement (acceleration, deceleration, speed, changes in direction, jumping, etc) whereas HIIT might be more suitable for speed-based conditioning in terms of the 1000m running. This possibility created can be implemented in several ways (short HIIT, long HIIT, continuous aerobic training, SSGs with several variations) where the control of volume, intensity, and objective will be left to the professionals' imagination [63]. Once again, we mention in table 5 that the players in the present study were not given enough minutes of aerobic training.

### *Study limitations*

The present study of the cohort has limitations and need to be recognized. First, no aerobic level assessments were made in the middle or at the end of the season. It is not known whether the overall aerobic capacity of players has changed and how much has changed over that period. Second, considering the specific positions of the athletes, it was not possible to verify the variation of $VO_2$max and the influence of the training program or injuries, as the positions were not isolated. Thirdly, we did not evaluate the training models and their choice during the season, which would provide us with more qualitative information about the possible influence on the athletes' aerobic performance. Fourth, the absence of dietary control, the recovery rate among sessions and the analysis of the athletes' stress may have influenced different perceptions of the internal training load despite both following the same training program. However, the message is clear, the players' aerobic capacity was low after preseason. One of the possibilities to correct the short time of the preseason only (4 weeks) is to maintain during the season the development of aerobic fitness for as long as possible [69]. In addition, although questionable, there are reports that lower aerobic capacity is such an important factor that can affect the final classification of the championship, the quality of the game, the intensity of displacements, and the distances covered in the match by players [26,71].

### *Practical applications*

This study shows such as the significant variability in $VO_2$max apply to professional players at a high competitive level. This study, despite its limitations, is evidence that individualization of training must be observed more than the collective response, as it often hides individual aerobic deficiency in many players. It appears that physical trainers must resist dogmatic advice to isolate and practice more evenly the distribution of physical qualities by applying the pragmatic concept of integrating mixed training models more often. Besides, some long-term observational studies suggest that $VO_2$max does not change over time or among different sessions [47] or is reduced insignificantly when players receive adequate minutes of aerobic training during the season [2]. Our results allow us to think and believe that the distribution of training loads in soccer players during the training program should emphasize intensities based on ventilatory thresholds one (VT1) and two (VT2) of milder intensities and alternating with the training model polarized - emphasizing significant load training doses that elicit 90%-100% of $VO_2$max using 4 x 4 min interval training [26,45]. This alternation of mixed models develops aerobic capacity through continuous and intermittent workout to be maintained throughout the athlete's season and career [66]. The alternating use within the training session it self using HIIT and SSGs during soccer player training seems to be an interesting alternative training model [67]. Perhaps the hypothesis raised by Halouani et al. [68] may be true, the isolated use of SSGs works better for players with high aerobic power, which was not the case in the present study. However, studies specifically related to soccer training are needed to support this. The ideal balance in aerobic and anaerobic workout is a crucial training component for higher performance. Although four weeks is considered a short period of time to reduce aerobic power, it is suggested in the transition period that emphasis be placed on aerobic training to minimize the effects of detraining in soccer players [73]. To improve fatigue endurance training, fitness trainers must take individual approaches while monitoring and prescribing physical workload, whether within technical and tactical exercises such as SSGs or generic running exercises such as interval and/or continuous training. The contemporary player feature is more universal [79 ].

## Conclusions

The $\dot{V}O_2max$ at the end of exercise training in four preseasons was not developed consistently with those previously verified in the literature [2,3,14,26,44,47,49,50,51,66]. The large number of elite professional soccer players with $\dot{V}O_2max$ below that recommended in the literature gives the impression of a lack of attention to this metabolic variable by the teams' technical committees. Our results may show that the failure of raising $\dot{V}O_2max$ to levels on the scale of 60 $mL.min^{-1}.kg^{-1}$ or more in outfield players, as shown in the literature, will show that the player will have difficulty compensating for energy expenditure soccer matches. Aerobic fitness is a critical physical component of soccer field success and should not be overlooked in a fitness program. In addition, a low $\dot{V}O_2max$ is considered an independent predictor of in-season injury. It is equally important for trainers to realize that there are many different ways to develop aerobic fitness, but it must be monitored. The results of the present study make us believe that, at least in the four seasons and during the preseason, the aerobic training model was little explored and it was not enough to significantly increase the $\dot{V}O_2max$ of the athletes.

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