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Effects of an 8-Week Pre-seasonal Training on the Aerobic Fitness of Professional Soccer Players

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Abstract

Michaelides, MA, Parpa, KM, and Zacharia, AI. Effects of an 8-week pre-seasonal training on the aerobic fitness of professional soccer players. *J Strength Cond Res* XX(X): 000–000, 2019—Pre-season in soccer training develops the physical requisites for competition and usually consists of a high volume of aerobic and anaerobic conditioning training including friendly games. The purpose of the study was to determine the effects of pre-season training on the aerobic fitness of professional soccer players. Nineteen professional male soccer players (age = 27.37 ± 3.67 years, height = 179.61 ± 5.17 cm, and body fat percentage = 11.3 ± 3.19%) participated in this study performed an incremental cardiopulmonary exercise testing on a treadmill before and after the 8 weeks of pre-season preparation. The results were analyzed using paired *t* tests, revealing significant differences on several indices. The subjects improved significantly on maximal aerobic capacity ($\dot{V}O_2$max) and lasted significantly longer on the treadmill ($p < 0.005$). The $\dot{V}O_2$ at ventilatory threshold (VT) and respiratory compensation point (RCP) increased significantly ($p < 0.005$). The running velocity at ventilatory thresholds (vVT and vRCP) and at $\dot{V}O_2$ max (v$\dot{V}O_2$max) also increased significantly ($p < 0.005$). In conclusion, the results of this study, as expected, demonstrated that the proposed 8 weeks of pre-season training program was sufficient to cause significant improvements on the aerobic performance indices of professional soccer players. The study confirms the beneficial changes in the process of adaptations that occur with this type of training and can assist coaches and trainers in planning a successful pre-season training program.

Key Words: fitness testing in soccer, lactate threshold, pre-season training

Introduction

The pre-season training period in soccer aims at developing the physical requisites for competition. Unlike individual sports, soccer is characterized by a shorter pre-season training period and a longer competitive training period, especially when teams participate in international competitions (9). This requires careful strategic planning for training periodization because the pre-season training period consists of intense conditioning as well as a number of friendly games in addition to the technical and tactical practices that are concurrently scheduled (12). Consequently, the training load during the pre-season training period is higher than that of in-season training (20) and is expected to cause significant training adaptations on the aerobic system. Interestingly, recent studies (10,18) demonstrated that when short intense running intervals (RIs), 30 seconds–4 minutes, are combined to the basic training volume, aerobic performance enhances significantly. Bangsbo (1) demonstrated that 90% of the total energy during a soccer game is supported by aerobic metabolism. Thus, the major aim of the pre-season training period is to increase aerobic capacity that translates into increased running activity and decreased walking time during competitive soccer games (19). Helgerud et al. (14) demonstrated that maximal aerobic capacity ($\dot{V}O_2$max) enhancement leads to improved soccer performance, substantiated as increases in the distance covered, the level of work intensity, the number of sprints, and the number of involvements with the ball during competitive games. Although $\dot{V}O_2$max fluctuates in professional soccer players (4,5,13,15,24,27,38), those who compete at superior playing standards and championships demonstrate greater levels (26,38). The greater $\dot{V}O_2$max gain, however, is usually evident after a successful pre-season training program, specifically at the beginning of the competitive season (15,27). The improvements observed are attributed to a higher aerobic contribution and the reduced involvement of the anaerobic energy system in energy expenditure (1). Evidently, running performance in endurance sports such as soccer is not only limited in high levels of $\dot{V}O_2$ max but also in other aerobic performance indices such as the lactate threshold (LT) and its associated running velocities (33). Thus, the purpose of this study was to examine the effect of the proposed 8-week pre-season training program on the aerobic performance indices of professional players.

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Methods

Experimental Approach to the Problem

This experimental design used an 8-week pre-season training program to examine its effects on the aerobic fitness of professional soccer players participating at the highest standard of the Cyprus Soccer League. Before the 8-week pre-season training period, the subjects went through cardiopulmonary exercise testing (CPET) on a motorized treadmill to determine their maximal aerobic capacity and its related indices. The results of the testing served to set up the training intensities for the RIs that were used during the 8-week pre-season period. On completion of the training program, the subjects were retested on the same protocol to examine the possible changes in their maximal aerobic capacity and adjust the training intensities for the in-season training modalities.

Subjects

Nineteen professional male soccer players (age = 27.37 ± 3.67 years, height = 179.61 ± 5.17 cm, and body fat percentage = 11.3 ± 3.19%) participated in this study. Participation in this study was

Table 1
Overview of the 8-week pre-season daily type of training.*

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
W 1							
AM	Off	Off	Off	Off	Off	Training	Off
PM	Training	Training	Training	Training	Training	Off	
W 2							
AM	Off	Training	Off	Training	Training	Training	Off
PM	Training	Training	Training	Training	Training	Off	
W 3							
AM	Training	Friendly game	Training	Off	Training	Friendly game	Off
PM	Training		Training	Training	Training		
W 4							
AM	Training	Training	Friendly game	Training	Off	Training	Friendly game
PM	Training	Training		Training	Training	Training	
W 5							
AM	Off	Training	Friendly game	Off	Off	Friendly game	Off
PM	Training	Training		Training	Training		
W 6							
AM	Off	Training	Friendly game	Off	Off	Off	Off
PM		Training		Training	Training	Training	Training
W 7							
AM	Off	Friendly game	Off	Off	Off	Friendly game	Training
PM	Training		Training	Training	Training		Off
W 8							
AM	Off	Off	Off	Off	Off	Official game	Training
PM		Training	Training	Training	Training		Off

*W 1–8 = pre-season weeks; AM = morning training; PM = afternoon training.

voluntary, and all subjects were informed of the benefits and risks of the investigation before signing an institutionally approved informed consent document to participate in the study. Goalkeepers were excluded from the study because these players do not participate in the same type of training sessions as the in-field players. The study was approved by the University of Central Lancashire Science, Technology, Engineering, Medicine and Health (STEMH) ethics committee board and the Cyprus National Committee on Bioethics (CNCB). All measurements were obtained between the hours of 9:00 and 15:00. To mitigate the effects of the circadian rhythm on performance, the subjects were retested about the same time of the day.

Procedures

Cardiopulmonary Exercise Testing. The pre and post pre-season period CPET was performed on a motorized treadmill (h/p/Cosmos Quasar med; H-P-Cosmos Sports & Medical GmbH, Nussdorf-Traunstein, Germany). The gas exchange measurements were collected on the Cosmed Quark CPET (COSMED, Rome, Italy) system, using a breath-by-breath analysis through reusable rubber masks (model 7940; Hans Rudolph, Kansas City, MO, USA). The device was calibrated as suggested by the manufacturer. The laboratory temperature was kept constant at 20 ± 2° C, and the relative humidity was 50%. The modified Heck incremental maximal protocol was used for the testing, as it was previously demonstrated to be valid and reliable on soccer players (34). The heart rate (HR) (Garmin wireless HR monitor; soft strap with ANT + sender, ~~China~~) was continuously monitored. AU8

Determination of Ventilatory Threshold and Respiratory Compensation Point. The ventilatory threshold (VT) and respiratory compensation point (RCP) were determined using different

Table 2
Training plan for weeks 1 and 2.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM	Off	Off	Off	Off	Off	Gym warm-up, circuit training 3, sets cool down	Off
PM	Warm-up, 3 runs × 1,200 m, passing drill, rondo 8v2	Warm-up, 3 runs × 1,200 m, passing control drill, possession	Warm-up, 4 runs × 1,000 m, technique drill, rondo	Warm-up, 4 runs × 1,000 m, technique drill, rondo	Warm-up, core training, 5 runs × 900 m, passing drill, possession	Off	
AM	Off	4-min running, dynamic warm-up, 6 runs × 900 m	Off	4-min running, dynamic warm-up, 7 runs × 900 m	4-min running, dynamic warm-up, 8 runs × 900 m	Gym warm-up, circuit training 3 sets, coordination/sprint	Off
PM	Core training, 4-min running, dynamic warm-up, 5 runs × 1,000 m, passing drill, tactic possession	Gym warm-up, circuit training 3 sets, coordination, rondo, possession, small game	Core training, dynamic warm-up, rondo, tactic/ small-sided game, small game	Core training, dynamic warm-up, rondo, tactic/ technique, small-sided game, small game	Core training, dynamic warm-up, rondo, small-sided game, tactic game	Off	

Table 3
Training plan for weeks 3 and 4.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM	4-min running, dynamic warm-up, 8 runs × 600 m	Friendly game	4-min running, dynamic warm-up, 8 runs × 600 m	Off	4-min running, dynamic warm-up, 4 runs × 600 m, 4 runs × 300 m	Friendly game	Off
PM	Gym warm-up, circuit training 3 sets, coordination, rondo, tactic game		Gym warm-up, circuit training 3 sets, coordination, passing drill, possession, tactic game	Handball, small game, rondo/football, funny game	Dynamic warm-up, sprint, rondo, set pieces, tactic game		
AM	4-min running, dynamic warm-up, 6 runs × 300 m, 6 runs × 200 m turn, 6 runs × 150 m turn	Gym warm-up, field, strength openings, 10 runs × 40 m turn	Friendly game	4-min running, dynamic warm-up, 8 runs × 150 m turn, 8 runs × 120 m turn, 8 runs × 90 m turn	Off	4-min running, dynamic warm-up, 10 runs × 50 m, 8 runs × 80 m, 6 runs × 100 m turn, 6 runs × 80 m turn	Friendly game
PM	Dynamic warm-up, rondo, possession, transition, small-sided game, tactic game	Dynamic warm-up, sprint, rondo, set pieces/ finishing, tactic game		Dynamic warm-up, plyometrics/elastic/ coordination/finishing, tactic possession, tactic game	Dynamic warm-up, rondo, tactic, funny games	Dynamic warm-up, sprint, rondo, tactic game/set pieces	

criteria. The VT was determined through the V-Slope method, the point at which the increase in the rate of elimination of carbon dioxide ($\dot{V}CO_2$) is greater than the increase in $\dot{V}O_2$. The VT point was verified at the nadir of the $VE/\dot{V}O_2$ curve. The RCP was determined at the nadir of the $VE/\dot{V}CO_2$ curve (2,37). The plots used for the determination of the thresholds utilized filtered breath-by-breath values (averaged into 10-second bins).

Pre-season Training Structure. A general overview of the 8-week pre-season program is presented in Table 1 and includes the categorization of the types of training as described by the coaching team. The pre-season period included 26 single training sessions, 12 double training sessions, 9 friendly games, and 6 rest days before the first official game. The detailed training modalities during the 8-week pre-season period are presented in Tables 2–5. The duration of morning training sessions (AM) was approximately 60 minutes, whereas the duration of afternoon training sessions was approximately 80–95 minutes.

Running Intervals. Weeks 1–5 consisted of several sessions of RI. The running distances covered are presented in Tables 2-4 in the form of number of runs × distance in meters. The running intensity was individualized based on the initial pre-season period testing treadmill running speed at RCP and at $\dot{V}O_2$max (vRCP and vVO_2max and max effort). Sprint interval training (SIT) included distances of up to 40 m. High-intensity interval training (HIIT) was divided into 3 levels: (a) Intervals of 50–100 m were set at running speed based on the individual's 140% of vVO2max. (b) Intervals of 150–300 m were set at running speed based on the individual's 110% of vVO_2max. (c) Intervals between 300 and 600 m were set at running speeds based on the individual's vVO_2max. Tempo runs consisted of a running speed set on the individual's vRCP. The exercise-to-rest ratios (passive recovery) were set according to the guidelines provided by Iaia and Bangsbo (18) where max intensity bouts (2–10 seconds) received 50–100-second rests, 70–100% of max speed bouts (10–40 seconds) received rest intervals of about 5 times the exercise duration, and

Table 4
Training plan for weeks 5 and 6.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM	Off	Gym warm-up field, strength openings, 10 runs × 40 m turn, 8 runs × 50 m turn, 6 runs × 80 m turn	Friendly game	Off	Off	Friendly game	Off
PM	Mobility warm-up, passing drill, rondo, starters 60-min recovery, nonstarters training	Dynamic warm-up, rondo, tactic game/set pieces		Mobility warm-up, passing drill, rondo, starters 60-min recovery, nonstarters training, mobility warm-up	Dynamic warm-up, rondo, tactic game/set pieces		
AM	Off	Gym, dynamic warm-up, hurdles, strength running, small-sided games, small game	Friendly game	Off	Off	Off	Off
PM		Dynamic warm-up, sprint, rondo, tactic, set pieces		Starters recovery, nonstarters training	Passing warm-up, passing, basket/handball, funny, rondo	Dynamic warm-up, plyometric/elastic coordination/finishing, transition, tactic game	Technique, funny games

Table 5
Training plan for weeks 7 and 8.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM	Off	Friendly game	Off	Off	Off	Friendly game	Starters recovery, nonstarters training
PM	Dynamic warm-up, sprint, rondo, tactic game, set pieces		Starters recovery, nonstarters training	Warm-up, rondo, funny games, set pieces	Dynamic warm-up, sprint, rondo, tactic game, set pieces		Off
AM	Off	Off	Off	Off	Off	Official game	Starters recovery, rest players training
PM		Gym, dynamic warm-up, mobility, strength running, small-sided games, small game	Dynamic warm-up, plyometrics/elastic/coordination/finishing, transition, tactic, tactic game	Technique, rondo, funny games	Dynamic warm-up, sprint, rondo, set pieces		Off

50–100% of max speed bouts (5–90 seconds) received rest intervals of about 1–3 times the exercise duration. The intervals [T3] that indicate "turn" in Tables 3 and 4 included 180° turns every 30 m. The formula used to determine the time (seconds) needed to complete the intervals was [3600 × interval distance (meter)]/[running speed ($min \cdot h^{-1}$)].

Other Types of Training Modalities During the Pre-season Training Period. Tables 2–5 summarize the different types of training modalities that took place during the 8-week pre-season training period. The athletes typically performed 3 sets for each of the training modalities. The *4-minute runs* (Tables 2–3) mostly consisted of pace runs to warm-up the players. The *dynamic warm-up* included dynamic stretching of the hip muscles followed by skipping ladder and passing drills. *Hurdles* was a type of plyometric training that included hopping over a series of 30- and 50-cm tall hurdles followed by short 10-m sprints. The term *strength running* is an indicator of light running drills combined with agility sprints through cones or agility poles, with or without a ball. *Rondos* included small possession games in a restricted area allowing only one-touch passes while a smaller group of players (sometimes only one player) tried to gain possession (5 vs. 1, 6 vs. 2, and 9 vs. 3). *Funny games* were low-intensity drills that combined skills and collaborative work. These included juggling walks in teams, footvolley, and heading passing. In general, the purpose of these drills was to prevent the ball from touching the ground, allowing the subjects to work on their skills. The *plyometrics/elastic/coordination/finishing* included jumping up on 4 plyometric boxes (30-45-60-75 cm), followed by a run against resistance (68-kg resistance band-Acceleration trainer Stroops) in 3 directions (diagonal-forward-diagonal, 10 m each), then advancing through a series of agility poles (zig-zag direction), receiving a pass, and, finally, attempting to score a goal against a goalkeeper (1 vs. 1). *Circuit training* consisted of a series of exercises on 6 stations (3 sets of 30-second efforts) that included body weight squats, push-ups, sit-ups, supported lunches on a suspension trainer (TRX), 2-legged balances on a balance trainer (BOSU) and, finally, front isometric plunks. The term *tactic* in Tables 2–5 refers to small-sided games (SSGs) used by the coaching staff to prepare the plan for the friendly games. The time varied according to the coaching staff plans. Similar to *tactic*, *small games* were SSGs in a restricted playing area (65 m long). The *transition* drills were also SSGs that typically included 3 color-coded teams. Their purpose was to develop the players' ability to quickly transition from defensive to attacking positions and vice versa. The players in one team followed the instructions of the

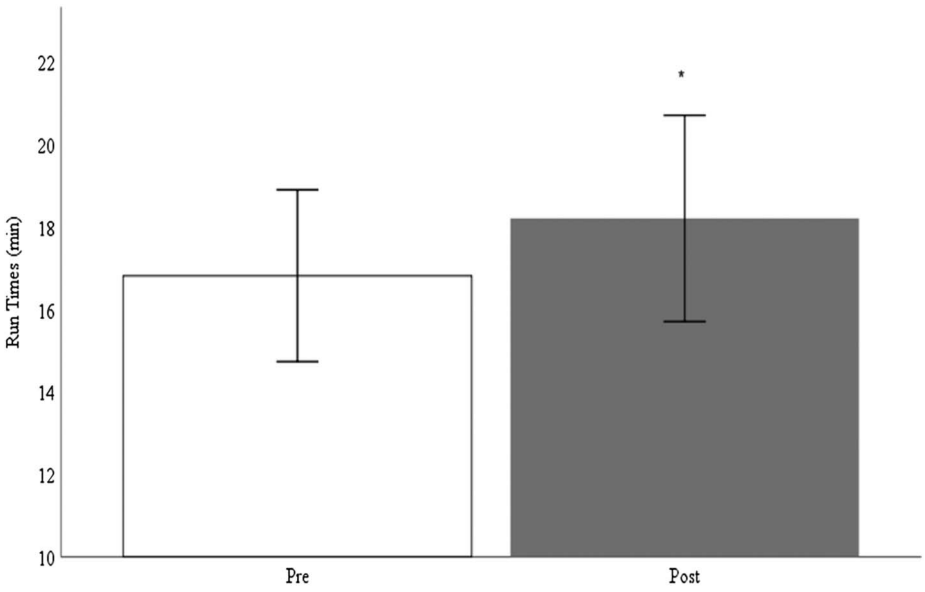

Figure 1. Mean run times before and after the pre-season training; *$p < 0.001$; error bars are *SD*.

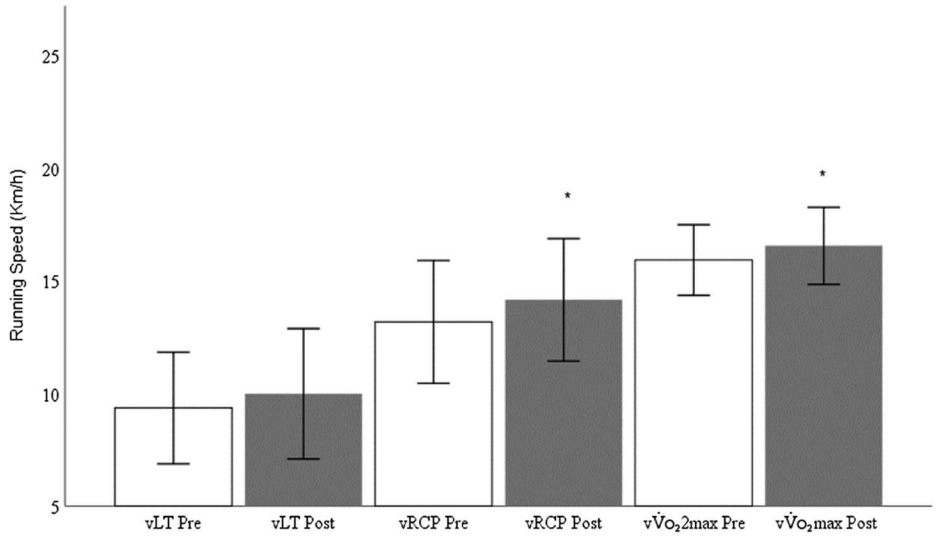

Figure 2. Running speeds before and after pre-season training at LT, RCP, and $\dot{V}O_2$ max; *$p < 0.001$; error bars are *SD*. LT = lactate threshold; RCP = respiratory compensation point.

coaching staff to collaborate with another small group of players against a third group. The aforementioned high-intensity transition drills were repeated 3 times and lasted for about 3 minutes with 2-minute rest intervals. The *handball* sessions were collaborative passing games. The players were restricted to passing the ball using their hands and score against another group of players only with a header.

Statistical Analyses

SPSS 25.0 for windows (SPSS, Inc., Chicago, IL, USA) was used for analyzing the results. Normality and homogeneity of variances were examined and verified using the Shapiro-Wilk and the Brown and Forsythe tests, respectively. The mean and *SD* were calculated for all parameters. Paired *t*-tests were used to examine the differences between the pre and post pre-season training period in both the anthropometric and aerobic fitness measures. Bonferroni adjustments were performed to avoid the inflation of getting at least one significant difference by chance. Thus, the level of significance was set at $p \leq 0.005$ ($a = 0.05 \times 10^{-1}$).

Results

The statistical analysis demonstrated that the subjects improved significantly in $\dot{V}O_2$max ($t_{(18)} = -5.86$, $p < 0.001$), CI-95% = −4.60 to −1.58 ($ml \cdot kg^{-1} \cdot min^{-1}$); $d = 0.84$, and lasted significantly longer ($t_{(18)} = -8.69$, $p < 0.001$), CI-95% = −1.85 to −0.93 (minutes); $d = 1.21$, on the treadmill after the 8-week pre-season training.

Furthermore, the HR decreased slightly but not significantly at ventilatory thresholds (VT and RCP) and $\dot{V}O_2$max with values recorded after pre-season training at 141 ± 15, 170 ± 9, and 184 ± 8 $b \cdot min^{-1}$, respectively.

The running velocities at VT (vVT) ($t_{(18)} = -2.04$, $p < 0.05$), CI-95% = −1.52 to 0.26 ($km \cdot h^{-1}$); $d = 0.47$, RCP (vRCP) ($t_{(18)} = -4.87$, $p < 0.001$), CI-95% = −1.57 to −0.40 ($km \cdot h^{-1}$); $d = 0.72$, and $\dot{V}O_2$max (v$\dot{V}O_2$max) ($t_{(18)} = -4.47$, $p < 0.001$), CI-95% = −1.04 to −0.23 ($km \cdot h^{-1}$); $d = 0.77$ increased significantly ($p < 0.001$). AU9

The $\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$) at VT ($t_{(18)} = -3.78$, $p < 0.001$), CI-95% = −6.65 to −0.90; $d = 0.69$ and RCP ($t_{(18)} = -3.66$, $p < 0.001$), CI-95% = −7.17 to −0.86; $d = 0.79$ also increased significantly ($p = 0.002$) (Figures 1–3). [F1] AU10

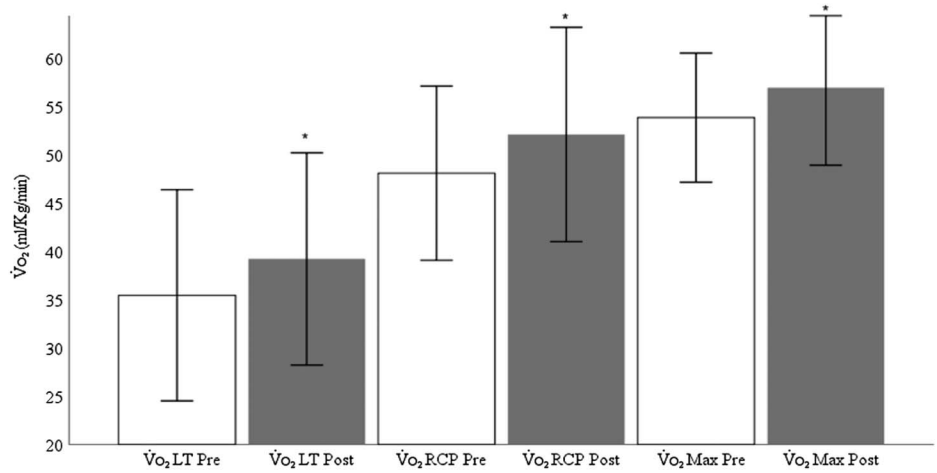

Figure 3. Oxygen consumption before and after pre-season training at LT, RCP, and $\dot{V}O_2$ max; *$p < 0.001$; error bars are *SD*. LT = lactate threshold; RCP = respiratory compensation point.

Discussion

This study demonstrated that the proposed 8-week pre-season training program caused significant improvements on all the aerobic performance indices of the professional soccer players. The effects of pre-season training on the aerobic fitness indices of professional soccer players are rather unsystematic in the findings of previous research. Although some studies demonstrated marked increases in $\dot{V}O_2$max after the pre-season training period (15,21,27,28), others have shown minimal or no changes (4,30,38). This inconsistency in the literature could be due to differences in scheduling and training philosophies across coaching teams, or due to a "ceiling effect," because higher standard, players are constantly on their maximal aerobic capacity, as suggested by Hoff et al. (16). The current study showed a significant improvement of about 6% in $\dot{V}O_2$max at the end of the 8-week preparation period. This is an indication that the pre-season exercise program of this study was effective in improving the aerobic fitness, with the increases reported to be similar to the ones reported previously (19,21). Although $\dot{V}O_2$max may provide a useful indication of the aerobic capacity of elite players (33), other aerobic performance indices, such as the LT, could be more sensitive to training than $\dot{V}O_2$max. In sports with predominance in aerobic system contribution, LT might be a better indicator of aerobic endurance performance than $\dot{V}O_2$max. Previous research demonstrated that LT (usually expressed as % $\dot{V}O_2$max) may continue to improve with training in relation to $\dot{V}O_2$max, a process controlled by a different physiological mechanism (11). In addition, the VT of professional soccer players could be further enhanced without any significant change in $\dot{V}O_2$max during the competitive season (4,7). This is important for the fitness coaches because blood lactate accumulation and its associated ventilatory changes are common threshold concepts that are used for setting up training intensities (3,25,29,36). In this study, the VT and RCP were detected at 65.63 ± 9.97% and 88.26 ± 5.88% of the $\dot{V}O_2$max, respectively, before the pre-season training period. The 8-week pre-season training in this study caused significant increases in both VTs. In particular, both the VT and RCP were detected at 67.88 ± 7.29 and 90.31 ± 4.42% of the $\dot{V}O_2$max (Figure 3). The most common method for detecting and monitoring endurance characteristics is to determine the $\dot{V}O_2$ and running velocity at a fixed blood lactate concentration of 4 mmol·L^{-1} (21,40). The VT was previously found to coincide with the LT (4 mmol·L^{-1}) in soccer players, and both increased from about 80 to 86% of $\dot{V}O_2$max after the pre-season training period (7,14). Although improvement in aerobic fitness coincides with reductions in HR response (39), the HR in this study demonstrated small but not significant decreases probably because of the short training period (11). In addition, vLT and v$\dot{V}O_2$max were found to increase significantly after the pre-season training period (1). Ziogas et al. (40) demonstrated that soccer players of higher playing standards had a greater vLT on the commencement of the pre-season training period. In addition, Kalapotharakos et al. (21) pointed out the practicality of using the v$\dot{V}O_2$max on assessing the aerobic demands of running and reported a 9.1% increase after the pre-season period. In this study, the running velocities vVT, vRCP, and v$\dot{V}O_2$max were significantly improved after the pre-season training period by 6.76, 7.50, and 3.82%, respectively. The pre-season training in this study resulted in the vVT and vRCP to occur at 60 and 86% of the v$\dot{V}O_2$max, respectively, and that is typical for highly trained athletes (6). The vRCP detected at 13.17 km·h^{-1} before and increased significantly at 14.15 km·h^{-1} after the pre-season training period, whereas the v$\dot{V}O_2$max also increased significantly from 15.92 to 16.55 km·h^{-1}. Similar running velocities were reported by others (4,14,21,34) after the pre-season training period. The beneficial effects of pre-season training on the running velocities at various thresholds can be of high importance. For instance, v$\dot{V}O_2$max in soccer has been found to positively correlate with the distance covered and the running intensity of professional soccer players (32). Furthermore, running speeds at maximum lactate steady state were found to improve the ability to use oxygen and, subsequently, to enhance metabolite removal (35).

Recent studies demonstrated that RIs such as high-intensity intermittent exercise training and speed endurance training drills improved the skeletal muscle oxidative capacity as well as exercise performance (10), and were superior to moderate-intensity training organized as SSG (31). As it concerns the intervals performed in this study (Tables 2–4), exercise duration was reduced from week 1 to week 5, whereas the intensity and the rest durations always increased in relation to the vRCP and v$\dot{V}O_2$max running speeds. The intensity and duration of the sessions were reduced during week 8 to prevent the development of a catabolic environment at the beginning of and during the competitive season (22). Combining RIs to soccer-specific training has a significant effect in aerobic fitness (about 7% increase in $\dot{V}O_2$max and LT) only 4 weeks into the pre-season training period (19). In addition, the combination of soccer-specific training with SIT may also provide further improvements during the in-season period. For instance, Ferrari Bravo et al. (8) observed 6 and 3% increase in $\dot{V}O_2$max and RCP, respectively, using SIT twice a week (3 × 6 maximal shuttle sprints of 40 m), which was superior to HIIT (4 sets of 4 minutes at 90–95% of HR max with 3 minutes of active recovery at 60–70% of HR max).

Most studies highlight the importance of using thresholds to indicate and monitor the improvements in aerobic performance indices during each period of a typical soccer season (21,40). In addition, they use specific exercise modalities, such as various types of interval training, embedded in the regular training to demonstrate further improvements (10,31). This study aimed to present a complete spectrum of the pre-season training program including the RIs. The major limitation of the current study is the lack of training load for the remaining of the training modalities, as this requires GPS tracking devices. Thus, the contribution of the RIs used in this study vs. the rest of the training modalities on the demonstrated improvements of the aerobic performance indices is unknown. In addition, the use of RCP as the threshold is limited in the literature. The onset of RCP is depended on the hypoxic ventilatory chemosensitivity of the carotid bodies and the rate of lactic acid increase (37). Additive triggering mechanisms such as muscle afferents and other sensory inputs from exercising muscles have been proposed (29). However, the RCP's effectiveness as threshold for training intensity in sports is unknown and questionable (23).

In conclusion, the results of this study, as expected, demonstrated that the proposed 8 weeks of pre-season training program was sufficient to cause significant improvements on the aerobic performance indices of professional soccer players. The findings before the pre-season training period, along with the equivalent improvements, are in line with the aforementioned literature. The effectiveness of the proposed program on the aerobic performance indices was evident from the increases in the VT, RCP, and $\dot{V}O_2$max presented in terms of %$\dot{V}O_2$max and running speeds, respectively. The increases observed demonstrate physical preparedness and suggest that players will be able to afford improved

pacing strategies and repeated sprint performance (also related to vLT and vVo_2max) during competitive games (1,14,19,40).

Practical Applications

Physical fitness coaches should use the results from the physiological tests to monitor and adjust the training intensities of their players. Aerobic performance indices such as $\dot{V}o_2$ max, VT, and running velocities at the thresholds (vVT, vRCP, and vVo_2max) are practical indicators to monitor aerobic performance. The proposed pre-season training caused significant improvements on the aerobic fitness that infers higher performance during the competitive season. Furthermore, the study demonstrated how a range of RIs divided into tempo runs, HIIT, and STI were used in combination to the various soccer-related training modalities to improve the aerobic fitness. In addition, the study provides useful information on how the running velocities were adjusted based on the vRCP and vVo_2max. Careful planning is needed to gradually increase the intensity of the intervals and adjust the volume to avoid injuries by including more soccer-related training such as SSG, technical-tactical drills, and participation to friendly games. Despite the fact that we are unable to isolate the contribution of the presented training modalities on the current improvements, the study can assist coaches and trainers in planning a successful pre-season training program.

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