INDIVIDUAL MATCH PLAYING TIME DURING THE SEASON AFFECTS FITNESS-RELATED PARAMETERS OF MALE PROFESSIONAL SOCCER PLAYERS

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ABSTRACT

Silva, JR, Magalhães, JF, Ascensão, AA, Oliveira, EM, Seabra, AF, and Rebelo, AN. Individual match playing time during the season affects fitness-related parameters of male professional soccer players. *J Strength Cond Res* 25(10): 2729–2739, 2011—The purpose of this study was to analyze the effects of an entire season on physical fitness parameters (PFPs) in male professional soccer players ($N = 18$). Performance in 5- and 30-m sprint (T5 and T30), countermovement jump (CMJ), agility (*T*-test), knee extensor (KE) and knee flexor (KF) isokinetic strength, hamstrings/quadriceps strength ratio (H/Q) and bilateral differences (BDs), and Yo-Yo intermittent endurance test 2 (YYIE2) was evaluated in 4 moments (E1–E4) throughout the season. Individual match playing time was quantified. Significant improvements in CMJ and YYIE2 from E1 to E2 were observed ($p < 0.05$–0.01). The T30 improved from E2 to E3 ($p < 0.01$). The CMJ decreased from E2 to E3 and E4, and YYIE2 from E2 to E4 ($p < 0.05$). There were increments in the H/Q ratio and Agility from E1 and E2 to E3 and E4 ($p < 0.05$–0.01). Significant correlations were found in all evaluation points between different PFPs and between changes in strength parameters and agility, T5 and T30, CMJ, and YYIE2 ($p < 0.05$–0.001). Influence of individual match playing time was correlated to changes in T5 (E1 to E3; $r = -0.705$), KE nondominant leg (KEND; E2 to E3; $r = 0.786$), and KF (E3 to E4; $r = 0.575$–0.590). The interrelationship between muscle strength (e.g., KE), sprint (e.g., T5), and jump abilities (CMJ) suggests the importance of muscle strength and power training for soccer. This study suggests that the systematic participation of the players in soccer matches favors the increase and maintenance of soccer players KE and KF muscle strength and sprint ability (T5). Thus, given the unique demands of actual match play, coaches should try to incorporate a competitive friendly match in the weekly training cycle of nonstarter players.

KEY WORDS soccer season, training schedule, training status, strength, muscle power, intermittent endurance

INTRODUCTION

The regular evaluation of soccer players' physical fitness using different tests is of special importance because players should be able to successfully compete during 10–11 months.

Data from different studies suggest that elite soccer players cover 8–13 km during matches (7) at a mean intensity close to the anaerobic threshold (AT) (43). Moreover, energy expenditure during match averages 70–75% of maximal oxygen consumption ($\dot{V}O_2max$) (7,38), which suggests that performance at the elite level may, in part, be determined by aerobic fitness (38). However, despite low- to medium-intensity running being the predominant activity pattern of soccer players, muscle power-based efforts, such as sprints, jumps, duels, and kicking, which are mainly dependent on maximal strength and anaerobic power of the neuromuscular system (15), are essential factors to successfully perform in soccer. Therefore, it is consensual among the literature that soccer players' performance is intimately related to the efficiency of different energy-related systems (43).

During season, players are usually under prolonged physiological stress, as has been described in different studies. Analysis of soccer player during the season has revealed signs of oxidative (9) and functional stress (7,25), and immune system (36) and hormonal stress-related imbalances (25). In such conditions, the maintenance or improvement of player performance is not only determined by appropriate conditioning but also by the ability of the body systems to recover and regenerate after multiple

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stress stimuli (25). Therefore, to better understand the recovery pattern of the player under such demanding competitive stress conditions, a longitudinal coverage of physical performance in several time points throughout the season may be useful. However, there is a lack of studies concerning the effects of an entire season on physical fitness of professional players engaged in sport activities, including soccer. Most of the studies rely on particular functional or physiological data such as anthropometrics (11,13,25,31), $\dot{V}O_2$max and AT measurements (11,13,31,32), specific intermittent endurance test (6,36), exercise performance in incremental treadmill tests until exhaustion (11), muscle power through jump and sprint tests (4,11,30), and lower limb strength evaluated by isokinetic devices (30,31). Inconsistency has been revealed in the literature regarding the impact of training and competition in the variation of certain fitness parameters (4,10,11,13,25,30–32). Moreover, these observations resulting from longitudinal scanning of players fitness, and from the analysis of the short-term impact of diverse forms of strength (29,49) and endurance training (42,49), did not consider the influence of the cumulative amount of competition playing time. A study performed by Impellizzeri et al. (23), wherein rating of perceived exertion (RPE) was used to quantify the internal training load (RPE-Tld), showed that in weeks comprising 2 official matches, the RPE-Tld can represent about 50% of total weekly training load decreasing to 25% in weeks with only 1 match performed. Hence, a possible determinant factor of physical fitness over the season could be the cumulative amount of match playing time, a subject scarcely explored. Therefore, the purposes of this study were to examine the impact of the season in a group of fitness-related parameters and the association between their changes, considering the influence of individual match playing time (IMPT).

METHODS

Experimental Approach to the Problem

As presented in Figure 1, the different physical tests were performed in the same order and in the same period of the day on 4 time points of a soccer season (10–11 months) as follows: first (E1)–before the soccer season; early July); second (E2)–end of the preseason period (early August); third (E3)–middle of the season (January); fourth (E4)–end of the competitive season (May).

In each moment, players were evaluated for basic anthropometry, countermovement vertical jump (CMJ), sprint and agility abilities, leg extensor and flexor maximal strength, and Yo-Yo intermittent endurance test 2 (YYIE2). However, no YYIE2 data were collected at the midseason (E3) because of Club heavy match commitments at that time. Additionally, the players' individual time spent in the matches was recorded. The physical fitness measurements throughout different time points of the season allowed the analysis of seasonal fitness alterations, the relationship between the different fitness parameters, and the IMPT in physical fitness. The selected variables provide valid and reliable data for the evaluation of physical fitness parameters (PFPs), known to be directly (agility, sprint, jump, intermittent endurance) and indirectly (isokinetic strength parameters) related to soccer performance.

Subjects

A group of 23 male professional players competing in the Portuguese elite championship (rank 6 of the Union of European Football Associations) was initially involved in the protocol. As a result of injuries ($n = 2$) and transferences to other clubs ($n = 3$), 5 players were not considered in the analysis ($n = 18$; Table 1). Only players free from injury involved in the full training schedules were tested. In accordance with the Club policy, all soccer players underwent usual physical examination in the beginning of the season (e.g., blood sample analyses, rest electrocardiogram, lung x- ray).

The experimental protocol followed the Declaration of Helsinki of the World Medical Association for research with humans and was approved by the local Ethics Committee. All participants were fully informed about the aims, experimental protocol, and procedures and provided written informed consent.

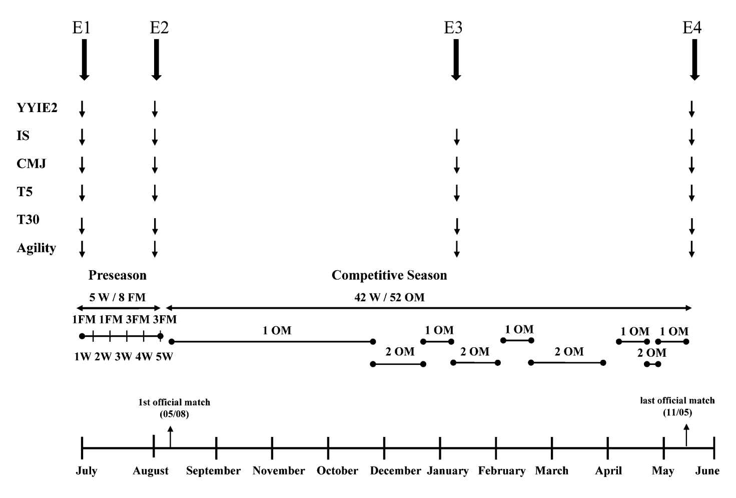

Figure 1. Season time line. E1 = evaluation moment 1 (before preseason); E2 = evaluation moment 2 (end of preseason); E3 = evaluation moment 3 (midseason); E4 = evaluation moment 4 (end of season); YYIE2 = Yo-Yo intermittent endurance test level 2; IS = isokinetic strength; CMJ = countermovement jump; T5 = 5-m sprint time; T30 = 30-m sprint time; W = week; 8FM = 8 friendly matches; 1OM = 1 official match per week; 2OM = 2 official matches per week; 1FM = 1 friendly match per week; 2FM = 2 friendly matches per week; 3FM = 3 friendly matches per week.

Table 1. Physical characteristics of the professional soccer players on the 4 test occasions.*†

Variable	E1	E2	E3	E4
Age (y)	25.7 ± 4.6	25.4 ± 4.7	26.9 ± 4.3	27.1 ± 4.3
Weight (kg)	76.5 ± 9.2	76.2 ± 9.3	76.3 ± 8.4	77.7 ± 9.1
Height (cm)	178.1 ± 5.7	177.8 ± 5.7	178.7 ± 6.6	179.1 ± 6.6
Fat mass (%)	9.8 ± 3.7	9.5 ± 2.7	9.3 ± 3.0	9.1 ± 3.1

*E1 = evaluation 1 (before preseason); E2 = evaluation 2 (end of preseason); E3 = evaluation 3 (midseason); E4 = evaluation 4 (end of season).

†Values are mean ± *SD*.

Evaluation Procedures

The CMJ, sprint ability, and agility tests were conducted in indoor facilities to exclude possible ground surface variations in the soccer pitch throughout the season. Before the tests, all the players performed a 10–15 minutes of warm-up consisting of light jogging, specific mobility exercises and stretching routine, and 10-m sprints. Players completed 2 rounds of each test in the same sequence, and the best result was considered for analysis. Each subject was allowed a minimum of 5-minute rest between tests to ensure adequate recovery. All the evaluations took place at the same time of the day, after regular overnight sleep. Players were instructed to maintain normal routines for daily food and water intake and followed the same dietary recommendations defined by the medical staff. In addition, during the days of physical tests, players were instructed to refrain from drinking beverages containing caffeine and alcohol and from consuming food during the 3 hours before testing. In the 2 days preceding evaluations, the players had a day off (first day) and a training session (second day) including low-intensity exercises aiming to improve postmatch recovery.

Physical Performance Tests

Countermovement Jump. The CMJ was performed using a platform, Ergojump (Digitime 1000, Digitest. Jyvaskyla, Finland) according to Bosco et al. (8), whereby the highest vertical jump (centimeters) and the longest flying time (seconds) were registered. The best trial of the 2 jumps was considered.

The apparatus consisted of a digital timer connected by a cable to a jump platform, Ergojump (Digitime 1000, Digest). The timer is triggered at take-off and then by participants' feet at the moment of touchdown. The subject started from an upright standing position on the platform, and immediately after an eccentric phase (corresponding to a semi squatting position), the participants jumped vertically without using arms (arms remained at both sides, hands on the hip throughout the tests).

Sprint Time. Sprint measurements were carried out using telemetric photoelectric cells (Brower Timing System, IRD-T175, Draper, UT, USA) mounted on tripods positioned approximately 0.75 m above the floor and situated 3 m apart facing each other on either side of the starting line (0 m), at 5 and 30 m. The players stood 0.3 m behind the starting line, started at their own discretion, being time activated when players cross the first pair of photocells, and they ran as fast as they could to complete 30-m distance. The fastest trial was considered.

Agility. Agility was evaluated through the *T*-test following the protocol of Semenick (41) with modifications (Figure 2). The subjects began with both feet 0.3 m behind the starting point A. At their own discretion, each subject sprinted forward 9.14 m (10 yd) to point B and touched the base of the cone with the right hand. They then sprinted to the left 4.57 m (5 yd) and touched the base of a cone (C) with the left hand. The subjects then sprinted to the right 9.14 m (10 yd) and touched the base of a cone (D) with the right hand. They then sprinted to the left 4.57 m back to point B and touched the base of a cone with the left hand. They turned 270° and then ran to point A, passing the finishing line. Two test trials were performed, and times

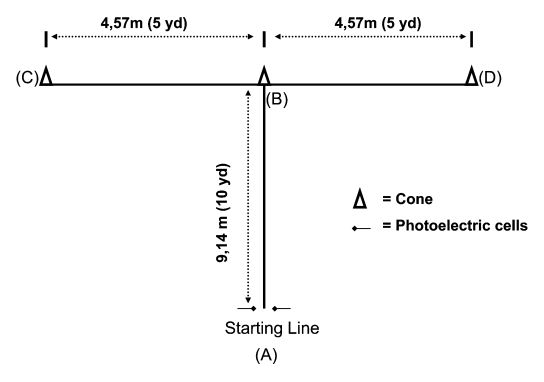

Figure 2. Layout of the *T*-test. Modified from Semenick (41). Brief explanation.

were recorded to the nearest 1/100th of a second. As described for sprint ability, measurements were carried out using telemetric photoelectric cells (Brower Timing System, IRD-T175). The players stood 0.3 m behind the starting line, being time activated when they passed the electronic sensors, and the clock stopped the instant players again crossed Point A. The fastest trial was considered.

Isokinetic Strength. To evaluate the players' lower limb muscle function, maximal gravity corrected concentric peak torque of quadriceps and hamstring, bilateral leg strength differences (BD), and ratio between concentric hamstring (H) and quadriceps (Q) peak torque values (H/Q) were measured during isokinetic knee joint movement (Biodex System 2, New York, NY, USA) of the dominant and nondominant (ND) leg at the angular velocity of $90°\cdot s^{-1}$ ($1.57\ rad\cdot s^{-1}$), according to Magalhães et al. (27). After individual self-report, the dominant leg was determined by a routine visual inspection in a simple target-kicking test requiring accuracy. Before muscle function measurements, subjects performed a standardized warm-up consisting of 5-minute period on a cycle ergometer (Monark E-824) with a fixed load corresponding to 2% of body weight. Players were then seated on the dynamometer chair at an 85° inclination (external angle from the horizontal) with stabilization straps at the trunk, abdomen, and thigh to prevent inaccurate joint movements. The contralateral leg was not secured to avoid influencing the strength developed by the knee being tested. The knee to be tested was positioned at 90° of flexion (0° = fully extended knee), and the axis of the dynamometer lever arm was aligned with the distal point of the lateral femoral condyle. Before the anatomical alignments and procedures, all the subjects were instructed to kick and also to bend the tested leg as hard and as fast as they could through a complete range of motion (from 90° to 0°). The subjects were also instructed to hold their arms comfortably across their chest to further isolate knee joint flexion and extension movements. All subjects also performed a specific submaximal warm-up protocol on the Biodex device to familiarize with the isokinetic device and test procedure. Three maximal repetitions at angular velocity $90°\cdot s^{-1}$ ($1.57\ rad\cdot s^{-1}$) were therefore carried out. The highest peak torque found during all the repetitions was chosen for the calculation of the BD. This parameter was calculated as follows: [(dominant concentric leg strength − ND concentric leg strength)]/dominant concentric leg strength × 100 and is expressed from absolute values as percentage, that is, independently of the difference direction (from dominant [D] to ND or ND to D). The ratio between concentric hamstring (H) and quadriceps (Q) peak torque values (H/Q) was also determined and expressed as percentage.

Yo-Yo Intermittent Endurance Test Level 2. The Yo-Yo tests were designed to measure the ability to perform bouts of repeated intense intermittent exercise. After a 10-minute warm-up, the players performed the test, which consists of repeated 2 × 20-m runs back and forth between the start and finish lines at a progressively increased speed controlled by audio beeps from a CD-ROM (5). The initial speed was $11.5\ km\cdot h^{-1}$ (12.5 seconds for 2 × 20 m), and between running bouts the participants had a 5-second rest period. The test was considered ended when the subjects failed twice to reach the starting line (objective evaluation) or the participant felt unable to complete another shuttle at the dictated speed (subjective evaluation) (12). The total distance covered during the YYIE2 (including the last incomplete shuttle) was considered as the testing score. Heart rate was measured during the YYIE2 and recorded every 5 seconds using an HR monitor (Polar Team System™, Polar Electro, Kempele, Finland). Field testing sessions were performed on the football pitch where players undertake their daily training sessions on several marked 2-m-wide and 20-m-long running lanes.

Intraclass correlation coefficients of all physical fitness tests were estimated using a test–retest procedure, with a random subsample of 9 subjects in each evaluation moment. The intraclass correlation coefficients (R) of all variables were high as follows: Height, weight, and fat mass: $0.93 \leq R \leq 0.99$; countermovement jump: $0.80 \leq R \leq 0.88$; sprint time: $0.71 \leq R \leq 0.87$; agility: $0.70 \leq R \leq 0.85$; Yo-Yo intermittent: $0.80 \leq R \leq 0.97$; and isokinetic strength: $0.78 \leq R \leq 0.98$.

Playing Schedule and Training Program

The generic training and competition plan completed by the soccer players involved in this study was supplied by the technical staff of the team. As can be seen by the season time line (Figure 1), 32 training sessions (6.4 per week) each lasting for 90–120 minutes per session, and 8 "friendly" matches for a total duration of 3,400 minutes were comprised between E1 and E2 (5 weeks). Training contents during this period consisted of 2 sessions per week of aerobic and strength training from week 1 to weeks 3 and 2 "friendly" matches. From weeks 4 to 5, 1 session per week of aerobic and strength training and 6 "friendly" matches were performed, 3 matches in each week. Aerobic training sessions consisted of general (interval running) and specific exercises (small-sided games and soccer specific circuits). Strength training sessions followed the specificity of strength training based on complex and contrast training (14).

Before training sessions, players performed a warm-up lasting approximately 20–30 minutes (5- to 10-minute jogging and low-intensity running, flexibility and mobility exercises, technical drills, short and brief explosive actions). After the training sessions, a warm-down that lasted approximately 10–15 minutes (jogging and stretching) was fulfilled.

Between E2 and E3 (25 weeks), first half of the in-season, the team performed 150 training sessions (6 per week) with a total duration of 13,300 minutes and played 26 official matches (1.04

TABLE 2. Variation of different performance measurements in the 4 evaluation moments throughout the soccer season.*†

Variables	E1	E2	E3	E4	GS
T5m (s)	1.032 ± 0.11	1.056 ± 0.05	1.017 ± 0.06	1.033 ± 0.07	1.033
T30m (s)	4.164 ± 0.18	4.217 ± 0.15	4.137 ± 0.14‡	4.16 ± 0.17	4.169
CMJ (cm)	42.44 ± 4.04	44.84 ± 4.5§	42.84 ± 4.4	42.23 ± 4.38	43.08
T-test (s)	8.714 ± 0.33	8.745 ± 0.36	8.408 ± 0.27‖	8.498 ± 0.27‖	8.591

*E1 = evaluation moment 1 (before preseason); E2 = evaluation moment 2 (end of preseason); E3 = evaluation moment 3 (midseason), E4 = evaluation moment 4 (end-of-season); GS = global sample; T5m = 5-m sprint time; T30m = 30-m sprint time; CMJ = countermovement jump.

†Values are mean ± *SD*.

‡$p < 0.01$ E3 vs. E2.

§$p < 0.05$ E2 vs. E1, E3, and E4.

‖$p < 0.01$ E3 and E4 vs. E1 and E2.

matches per week). In this period, players performed in each week 1 session of aerobic high-intensity training (high-intensity interval training and small-sided games), 1 session of functional strength training (plyometric training, resistive sprints, agility drills) and 1 session of others sprint ability exercises (with and without changes of directions).

Between E3 and E4 (17 weeks), second half of the in-season, players were engaged in 90 training sessions (5.3 per week) with a total duration of 7,200 minutes and played 26 official matches (1.5 per week). In this period, the number of matches increased, and the number of fitness training sessions decreased.

Statistical Analyses

All data are reported as mean and *SD*. Normality was tested with the Shapiro–Wilks test. Intraclass correlation coefficient was calculated to estimate the reliability of the physical fitness tests. Analysis of variance for repeated measures was used to compare the differences between evaluations. Pearson correlation coefficients (r) were used to determine association between tests, tests changes, and their relationship with individual match playing time. The SPSS statistical package (version 14.0; Inc., Chicago, USA) was used. Statistical significance was set at $p \leq 0.05$.

TABLE 3. Variation of isokinetic strength measurements in the 4 evaluation moments throughout the soccer season.*†

Variables	E1	E2	E3	E4	GS
KED 90°·s^{-1}(N·m)	238.95 ± 39.8	240.73 ± 51.4	239.13 ± 45	243.96 ± 52.8	240.64
KFD 90°·s^{-1}(N·m)	131.22 ± 22.1	131.58 ± 21.9	135.36 ± 25.1	138.03 ± 24.2	134.05
H/Q D (%)	54.91 ± 6	54.65 ± 5	56.6 ± 8.5‡	56.4 ± 7.3‡	55.64
KEND 90°·s^{-1}(N·m)	241.746 ± 39	241.338 ± 47	241.85 ± 40	243.82 ± 53.3	241.417
KFND 90°·s^{-1}(N·m)	128.992 ± 19.6	128.561 ± 23.4	133.01 ± 20.1	133.86 ± 23.6	130.74
H/QND (%)	53.35 ± 4.9	53.2 ± 5.2	55.02 ± 5.4‡	54.9 ± 6.1‡	54.1
BDKE (%)	5.76 ± 5.36	5.57 ± 5.42	5.70 ± 4.95	8.54 ± 4.91	6.39
BDKF (%)	6.64 ± 6.3	5.59 ± 4.7	7.66 ± 5.4	7.6 ± 5.8	6.87

*E1 = evaluation moment 1 (before preseason); E2 = evaluation moment 2 (end of preseason) ; E3 = evaluation moment 3 (midseason) ; E4 = evaluation moment 4 (end-of-season); GS= global sample; KED = peak torque in knee extension dominant legs; KFD = peak torque in knee flexion dominant legs; H/Q D = concentric hamstrings/quadriceps strength ratio dominant leg; KEND = peak torque in knee extension nondominant legs; KFND = peak torque in knee flexion nondominant legs; H/QND = concentric hamstrings quadriceps strength ratio nondominant leg; BDKE = bilateral strength differences in extensors muscles; BDKF = bilateral strength differences in flexors muscles.

†Values are mean ± *SD*.

‡$p < 0.05$ E3 and E4 vs. E1 and E2.

TABLE 4. Variation of YYIE2 measurements in the 4 evaluation moments throughout the soccer season.*†

Variables	E1	E2	E3	E4	GS
YYIE2 (m)	1,120 ± 187.6	2,250 ± 296.4‡		1,640 ± 196§	1,670
HRmax ($b \cdot min^{-1}$)	197.9 ± 8.3	196 ± 7.1		196.1 ± 9.0	196.9
HRmean ($b \cdot min^{-1}$)	181.6 ± 9.6	180.9 ± 7		176 ± 9.8	179.5

*E1 = evaluation moment 1 (before preseason); E2 = evaluation moment 2 (end of preseason); E3 = evaluation moment 3 (midseason); E4 = evaluation moment 4 (end-of-season); GS = global sample; YYIE2 = Yo-Yo intermittent endurance test level 2; HRmax = maximal heart rate; HRmean = mean heart rate.

†Values are mean ± *SD*.

‡$p < 0.01$ E2 vs. E1.

§$p < 0.05$ E4 vs. E1 and E2.

RESULTS

Physical Performance Tests

The results of the physical tests performed in the 4 time points throughout the season are shown in Tables 2–4.

The best 5-m (T5) and 30-m (T30) results were obtained at E3, but significant differences were only observed between E2 and E3 in the T30 (Table 2).

The results of CMJ were significantly higher in the E2 compared with the other 3 time periods (Table 2). No differences were found between any other moments.

The *T*-test performance showed a significant improvement in E3 and E4 when compared with E1 and E2 (Table 2). No differences were found between E3 and E4 nor between E1 and E2.

No significant changes were found in knee extension (KE) and knee flexion (KF) strength in both dominant (D) and ND legs (peak torque in knee extension dominant legs [KED], peak torque in knee extension nondominant legs [KEND], peak torque in knee flexion dominant legs [KFD], peak torque in knee flexion nondominant legs [KFND]), and in BD in leg extension and flexion in the 4 time points (Table 3). However, a significant increase in the H/Q ratio was found from E1 and E2 to E3 and E4.

As mentioned, YYIE2 was only evaluated in E1, E2, and E4. The total distance covered during the YYIE2 significantly increased in E2 and E4 compared with E1. However, a significant decrease was also observed from E2 to E4 (Table 4).

Association between Tests

In E1, T5 was correlated with T30 ($r = 0.662$; $p < 0.001$) and *T*-test time ($r = 0.577$; $p < 0.01$). The T30 was also correlated with CMJ ($r = -0.456$; $p < 0.05$) and *T*-test ($r = 0.441$; $p < 0.05$). Moreover, significant correlations were observed between CMJ and KE values ($r = 0.524$ and 0.534 for KED [$p < 0.05$] and KEND [$p < 0.01$], respectively). In E2, significant correlations were found between CMJ and T30 ($r = -0.723$; $p < 0.01$), T5 ($r = -0.526$; $p < 0.01$), and *T*-test time ($r = -0.556$; $p < 0.01$). The T30 was also correlated with T5 ($r = 0.667$; $p < 0.01$) and *T*-test time ($r = 0.725$; $p < 0.01$). In E3, correlations were found between CMJ and T5 ($r = -0.508$; $p < 0.05$) and T30 ($r = -0.686$; $p < 0.01$), and also between T5 and T30 ($r = 0.801$; $p < 0.001$). Additionally, significant correlations between H/QND and the *T*-test were found ($r = 0.607$; $p < 0.01$). In E4, correlations between T5 and CMJ ($r = -0.730$; $p < 0.01$; Figure 3) were observed. The KED was correlated with the T5 ($r = -0.547$; $p < 0.05$), and H/QND was correlated with de CMJ ($r = 0.623$; $p < 0.01$). In all the evaluations, body mass was correlated with the peak torques from both KE and KF (r ranging from 0.6 to 0.8 and $p < 0.01$ to 0.001).

Association between Changes in the Tests

From E1 to E2, significant correlations were observed between individual changes in T30 and changes in CMJ ($r = -0.546$; $p < 0.05$) and KED ($r = -0.623$; $p < 0.01$). Changes in *T*-test time were correlated with changes in KFD

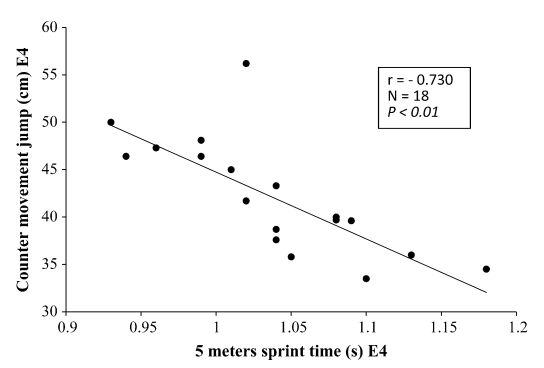

Figure 3. Relationship between countermovement jump (CMJ) and 5-m sprint time (T5) in E4.

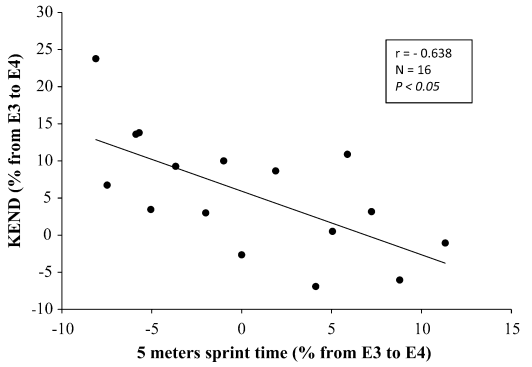

Figure 4. Relationship between changes in peak torque knee extensor nondominant leg (KEND) and 5-m sprint time (T5) from E3 to E4.

($r = 0.522$; $p < 0.05$) and H/QD ($r = 0.768$; $p < 0.001$). Also, a significant correlation between individual changes in KED and YYIE2 was observed ($r = -0.568$; $p < 0.05$). From E2 to E3, significant correlations were observed between individual changes in *T*-test time and H/QD ($r = 0.726$; $p < 0.05$). Also, changes in KEND were correlated with T5 ($r = -0.638$; $p < 0.05$; Figure 4), and changes in *T*-test time were correlated with H/QND ($r = 0.622$; $p < 0.05$) from E3 and E4.

Association between Match Playing Time and Changes in the Tests

The individual match playing time from E1 to E3 was correlated with the individual changes in T5 ($r = -0.705$; $p < 0.01$; Figure 5). From E2 to E3, the IMPT was significantly correlated with KEND ($r = 0.786$; $p < 0.05$) and H/QND ($r = -0.738$; $p < 0.05$). From E3 to E4, the IMPT was correlated with KFD ($r = 0.590$; $p < 0.05$), KFND ($r = 0.575$; $p < 0.05$) and H/QND ($r = 0.794$; $p < 0.05$, Figure 6).

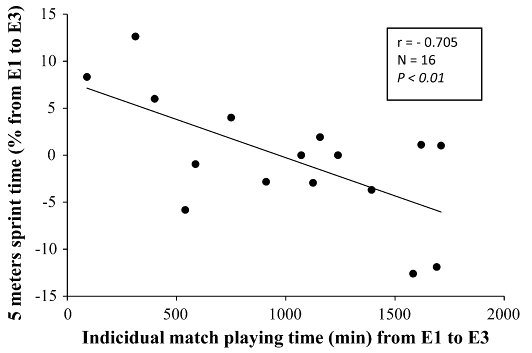

Figure 5. Relationship between individual match playing time (IMPT) and changes in 5-m sprint time (T5) from E1 to E3.

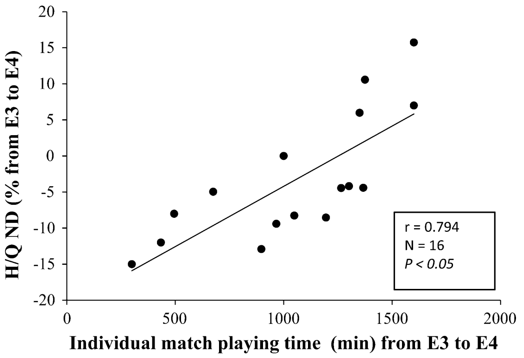

Figure 6. Relationship between individual match playing time (IMPT) and changes in hamstrings/quadriceps (H/Q) strength ratio nondominant leg (H/QND) from E3 to E4.

DISCUSSION

The purposes of this study were to examine the impact of the season in a group of fitness-related parameters and the association between their changes, considering the IMPT.

Our data showed that very short-sprint performance measured by the T5 is a stable physical ability throughout the soccer season. However, significant differences were observed in the T30, where the time to perform the 30-m distance decreased from E2 to E3 ($p < 0.01$) evidencing better sprint performance in the middle of the competitive period. In contrast with our data, Aziz et al. (4) reported a gradual improvement in sprint performance over the season in both 5- and 20-m sprint tests.

The soccer players showed a significantly higher CMJ performance in E2 than in E1, E3, and E4 (Table 2). Accordingly, Clark et al. (13) also found variations in CMJ throughout the soccer season. However, discrepancies regarding seasonal variation in CMJ performance have been reported in the literature. In fact, in contrast with our results, others did not report variations in CMJ during the season (11,30,31). The increase in CMJ performance in E2 could possibly be explained by the higher number of sessions dedicated to improve strength and muscle power during preseason. During this period, high training volumes are usual aiming to improve the general fitness levels (45) including muscle power. Moreover, around December before E3, and from E3 to E4, we observed an increase in the number of games (see Figure 1) requiring more time given to recovery interventions, which implies a reduction in the volume of strength and power training and potentially explain CMJ decrement from E2 to E3 and E4. The predominant use of functional strength or solely functional type of muscle training during in season may result in a decrement of the jump ability gains attained during preseason training (10, 39). Nevertheless, in a study by Caldwell and Peters (10), semiprofessional players only performing functional strength training during in season were able to further increase and maintain the improvements obtained during preseason.

Some researchers have suggested the importance of the agility as an independent physical variable in the assessment of male football players' performance (44,48). Our data showed improvements in agility performance from E1 and E2 to E3 and E4, with the highest scores being observed in E3. A better coordination between agonist and antagonist muscles allows an improved ability to stop, start, and turn rapidly while maintaining balance without loss of speed (41), which may explain, at least in part, our results. These actions that are systematically performed during training and games could likely contribute to the agility increase observed in E3 and E4.

All together, the results of the agility and sprint tests suggest that activities related with the stretch-shortening cycle (SSC [26]) were improved in the midseason (E3). However, CMJ was not improved in this period. One possible reason is that CMJ might not fulfill the criteria of SSC as would running-based exercises, which lie in a very fast transition from stretch to shortening phases and in a greater stretch velocity, both critical for stretch reflex activation (47).

Generally, data from our study showed that players maintain the same levels of strength in both knee extension and flexor muscles and bilateral strength differences throughout the soccer season. In fact, only significant increases in the H/Q ratio from E1 and E2 to E3 and E4 were observed. A stability of isokinetic strength parameters (e.g., KE) of professional soccer players over the season was also observed by other investigators (30). In contrast, amateur players showed a significant decrease of KE during an 11-week competitive soccer season (25). This fact may highlight the possible influence of training time in exercises specifically targeting muscle strength. Curiously, the KE peak torques observed in this study during the season were higher than those reported in professional soccer players even at lower angular velocities ($60^\circ\cdot s^{-1}$) (30,31). Possible differences in time devoted to strength training may contribute to explain, at least partially, the referred differences between studies. Nevertheless, it is important to refer that despite the popularity of isokinetic tests in research, they are less predictive of performance and longitudinally changes than isoinertial measures, because a high sensibility is expected when the mode of training matched the mode of testing (22).

Despite the multifactorial etiology of muscle injury, some evidence suggests that imbalances in H/Q, and BD (2,16), previous injury (2,17) and lower resistance to fatigue (e.g., hamstrings) (40), are major risk factors for soft tissues injuries of soccer players. Throughout the time course of our study, the H/Q ratios observed in the different time points were identical to those reported previously by our group (27) and lower than the results reported by others (31). Furthermore, Mercer et al. (31) did not report any significant changes in H/Q from the beginning to the end of preseason (E1 to E2). According to the improvements in CMJ during preseason and in agility during in season, it seems reasonable to suggest that a detraining effect may occur during offseason. In fact, there is scientific evidence that detraining effects are more marked in muscle power than in strength, the former being more dependent on muscle coordination (24,34).

The Yo-Yo Test is widely used to evaluate the ability of soccer players to intermittently perform exercise and has been considered a sensitive tool to detect seasonal changes in the fitness of soccer players (6). Our data showed an increase in the YYIE2 performance after the preseason period followed by a decrease at the end of season (E4). These results are in agreement with previous data reporting soccer players' lower intermittent endurance performance at the beginning of the season in field and laboratory tests. In fact, data obtained through different tests, such as the incremental treadmill test to exhaustion (32), exercise tolerance at $\dot{V}O_2$max, Intermittent Field Test (36), and the Yo-Yo Intermittent Recovery Test (6) expectedly revealed lower performance at the beginning of the season than during the competitive period. Unfortunately, because of practical constraints related to the competitive calendar of the team engaged in this study, no data have been collected during the midseason (E3), which enables one to assess the impact of the first half of the season in the ability to perform intermittent endurance exercise.

Despite some controversies regarding the eventual contribution of the players' aerobic power, the increments in YYIE2 performance in E2 and E4 compared to E1 may also be related to improvements in other endurance-related physiological features. Rampinini et al. (35) recently observed that time constant of $\dot{V}O_2$ Kinetics and the ability to maintain acid–base balance are also important physiological factors to the performance in Yo-Yo tests. As so, improvements in the former factors throughout the season may have increased the capacity to repeatedly perform intermittent endurance exercise. On the other hand, the lower levels of intermittent endurance observed in E1 may also explain the significant increment observed during preseason (E2), because in such conditions, higher adaptations should be expected.

The decline in YYIE2 performance observed in our study at E4 compared to that at E2 might be related to the specificity of the competition schedule. In fact, Mohr et al. (33) reported decreases in the ability to perform high-intensity running during games in elite soccer players involved in National and European competitions (2 matches per week) toward the middle of the season, during which there is limited time to fitness training and more time to recovery is needed. Accordingly, Kraemer et al. (25) observed that starter players who usually accumulate more match playing time experience greater performance decrements in some fitness parameters. Curiously, no relationship was observed in this study between changes in YYIE2 and IMPT.

An intriguing finding was that players with lower increments or higher decrements in KFD (E1 to E2), H/QD (E1 to E2 and E2 to E3), or H/QND ratio (E3 to E4) showed higher improvements in agility performance. These results suggest that improvements in flexors strength and H/Q ratios seem to be in the opposite direction of agility development. A possible explanation could be that the decrease in the H/Q strength ratio allowed the increment of acceleration capacity resulting from the increase of KE activation and from the reduction of the antagonist KF coactivation during the knee extension task (50).

The present results showed that improvements in KED from E1 to E2, KEND from E3 to E4 (Figure 4), and CMJ from E1 to E2 were significantly correlated with the performance improvement in short sprints. The KE also showed significant correlations with the CMJ (E1) and T5 (E4; KED). Moreover, high correlations between CMJ and T30 (E1, E2, and E3) and T5 (E3 and E4; Figure 3) were observed. Previous studies (19,48) showed that players with improvements in CMJ and in strength experienced improvements in short-sprint performance. As proposed by other researchers (19), this may suggest a possible transfer from leg power strength gains into enhanced sprint performance. In fact, there were significant associations between the different functional tests that rely on power activities (CMJ, T5, T30, and Agility; Figure 3) in the different evaluation time points. Moreover, from E1 to E2, we observed that the players with higher improvements in KED showed lower improvements in YYIE2 ($r = -0.568$; $p < 0.05$). However, during the same period, a higher improvement in YYIE2 was parallel to an improvement in a muscle power test (CMJ). It has been reported that concurrent muscle training and high-intensity interval training performed during preseason could lead to improvements both in muscle power (10- and 30-m sprint, vertical jump) and in intermittent endurance performance (YYIR1)(49). However, after the observation of an increment in both CMJ and YYIE2 performance during preseason in this study, no relationships between the 2PFPs and/or their changes were found.

Top-level soccer players are usually involved in the weekly matches of the national leagues and very often in international commitments. These competitive demands may impose strains to various physiological systems including musculoskeletal, nervous, immune and metabolic (7,9,25,36), to a point where the managing of player's physical fitness trough training and recovery strategies became influential to maximize match performance. Thus, the knowledge on the relationship between IMPT and PFP throughout the season would be helpful in the management of training programs including the time scheduling of official and "friendly" matches and specific training sessions.

During the 90 minutes of the match, soccer players can perform 10–20 sprints, a high-intensity running every 70 seconds, about 15 tackles, 10 headings, 50 involvements with the ball, and 30 passes, and changing pace and sustaining forceful contractions to maintain balance and control of the ball against defensive pressure (43). Therefore, high stress levels are imposed on the neuromuscular system to cope with this essential muscle power-based efforts. As already observed in other intermittent team sports such as handball (18,20), individual match playing time (IMPT) seems to influence players' fitness during season. In fact, according to our results, players with more accumulated IMPT from E1 to E3 showed higher improvements in T5 ($r = -0.705$; $p < 0.01$; Figure 5). This suggests that the short bursts of acceleration required during games could have a positive effect in developing players' ability to accelerate (15,48). It was observed that players with higher IMPT showed both higher increments and lower decrements in KEND ($r = 0.786$; $p < 0.05$; E2 to E3), KFD, and KFND ($r = 0.575$ and 0.590, respectively; $p < 0.05$; E3 to E4). Kraemer et al. (25) observed that during and after a 11-week competitive soccer season, collegiate soccer players' KF strength did not significantly decrease as much as KE did. Moreover, the authors observed that starter players showed higher values of KF in the different evaluation points. Additionally, we observed that the correlation coefficients between IMPT and individual changes in the H/Q ratio were $r = -0.738$ ($p < 0.05$) from E2 to E3 and changed to a positive value of $r = 0.794$ ($p < 0.05$) from E3 to E4 (Figure 6), reflecting the different impact of IMPT in KE and KF in the different evaluations throughout the competitive period. The observed relationship between IMPT and these PFP suggests that male professional soccer players with higher IMPT have higher capabilities to increase or maintain muscle strength (KE and KF) and sprint (T5) throughout the season, that is, competition time may possibly contribute to influence certain physical characteristics of professional soccer players. In fact, it was evidenced that after the game, KF is affected by fatigue and muscle damage and the KF reduction follows the increase in some indirect markers of muscle damage (1,3,28). Moreover, KF was also referred as a muscle group less resistant to fatigue than KE (40) that shows after a match higher force decrements (1,21) and longer period of muscle soreness (46) than extensor muscles. This may explain at least partially the higher adaptations found in this muscle group in players with more IMPT between E3 and E4. In fact, muscle adapts to training regimens that engage them in SSCs and are impaired less with repeated exposure (37).

PRACTICAL APPLICATIONS

This study showed that changes in different parameters of soccer players' fitness are observed throughout a soccer season. In this way, a proper control of training and competition workloads and their impact should be monitored. The preseason improvements in players' physical fitness from start (E1) to the end of the season (E4) makes it logical to conclude that during offseason players experienced pronounced effects of detraining in jump ability and agility, and intermittent endurance capacity. Thus, male professional soccer players should perform a specific training program or participate in active leisure activities to attenuate reductions in training status that result from offseason period and to better cope with preseason training loads. Coaches should be aware that the interrelationship between KE strength, 5- and 30-m sprint time, and CMJ performance suggests that muscle strength and power training should be an important component of soccer training. Moreover, given that during the in-season, the isolated completion of functional strength exercises may be insufficient to maintain the jump ability of professional players, the incorporation of some form of weight training (e.g., combined weight and plyometric training) might be beneficial. This study suggests that the systematic participation in soccer matches favors the increase and maintenance of male professional soccer players' muscle strength and sprint ability. Thus, given the unique demands of actual match play, coaches should try to incorporate a competitive friendly match in the weekly training cycle of nonstarter players.

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