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ORIGINAL ARTICLE

# Referees' physical performance over a soccer season

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## Abstract

**Background** An important role of soccer referees is to apply the rules of the game by observing the match closely. Thus, referees have to undertake training to keep up with play and attain an optimal position when making critical decisions. We analyzed the variation of the soccer referee physical performance during official championship.

**Methods** The referees were classified into three groups according to ages (16–20 years; 21–29 years; 30–45 years) and physical fitness variations were studied at the start (T0), at the middle (T1) and at the end of the competitive season (T2). In each period, Yo–Yo intermittent recovery test level 1 (YYIRT1) and 40 m sprint test were performed and $VO_{2max}$ assessed. Finally, the referees's rating (i.e. the mean of numerically quantification of the performances received during the season) was also evaluated.

**Results** The mean distance covered by the referees during the YYIRT1 test increased significantly from T0 to T1 and T2, and from T1 to T2, in all age groups, with a higher effect observed for group 16–20 years in all testing periods. This group significantly improved YYIR1 performance and $VO_{2max}$ at T1and T2. Referee ages correlated with differences ($\Delta$) in running speed test (40 m sprint test), of YYIRT1 and $VO_{2max}$. Finally, the referees' rating, based upon training, experience, performance and fitness assigned by qualified officials, ranged from 8.20 to 8.65. A positive correlation was found between the excellent rating and younger age ($p = 0.015$ by Chi-square test $\chi = 8.6$).

**Conclusions** The young referees performed better physical performances than adult referees and obtained better assessments by qualified officials.

**Keywords** Physical fitness · Soccer referees · YYIR1 · Running speed test · $VO_{2max}$

## Introduction

Soccer is known as the most popular sport in the world [1]. Attention is focused mostly to players and coaches, but referees play no less important role. The role of soccer referees and assistants is to apply the rules of the game observing the match closely. For this reason, it is important that they pay attention to the slightest movement of the players to avoid the violation of the rules and to prevent injury. To do it, referees and assistant referees have to do training as well as soccer players to keep up with play at all times to attain optimal positioning when making critical decisions [2]. Nevertheless, while physical and physiological features of soccer players, both males and females, are largely studied [3–10], there are few studies, which focus on soccer referees and assistants [11–15]. Dolański et al. [13] showed that the referee's mean heart rate was higher by 25 bt/min than that of the assistant, and the mean maximum heart rate was 184.9 bt/min for the referees and 166.6 bt/min for the assistants [13]. Soccer referees cover approximately 10–12 km [11, 16, 17] whilst assistants cover about 6.76 km [12]; they perform as much as 1269 activity changes during a match and may undertake 21.3–30.5 sprints at a speed above 25.2 km/h [16]. Referees' high-speed running distances decline during the

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later stages of the match [16] perhaps a sign of accumulated fatigue [11] due to the high physical and physiological match demands [2], as demonstrated by blood lactate increment and in sprint performance decrement [14]. Nowadays, soccer referees have additional fatigue due to the increase in the number of matches (at all competitive levels) in which they are involved during the season [18]. These data reinforce the view that soccer refereeing represents a demanding physical challenge; also, because referees are often older than soccer players [17].

Thus, specific endurance programs are necessary both during the competitive season [16, 19, 20] and the off-season period (between the end of a competitive season and the start of the following pre-season) [15]. Nevertheless, not many studies have examined seasonal adaptation in physical performance of soccer referees [19, 21], and, specifically, no study has also considered the age of the referee in assessing physical performance.

The assessment of physical capacities of athletes is one of the most important issues in modern sports. Coaches and sport scientists use field and laboratory tests for screening candidates, in selection procedures, or to monitor the efficacy of training regimes. Numerous field tests have been developed to assess the physical capacities of athletes; soccer referees included. Yo-Yo tests have rapidly become one of the most extensively studied shuttle run tests in sports science, due to their specificity and practicality [22]. These tests have also been applied to assess players' abilities to repeatedly perform high-intensity exercise [22] in many team sports such as soccer [23], basketball [24] and rugby [25]. It is thought that Yo-Yo tests are one of the most effective field-based means of assessing soccer player's endurance performance [25] and may meet the requirements of simultaneous stimulation of the aerobic and anaerobic energy system [26]. Particularly, the Yo-Yo Intermittent Recovery Level 1 (Yo-Yo IR1) test focuses on the capacity to carry out intermittent exercise leading to a maximal activation of the aerobic system, regardless of gender, competitive level and also of age [23].

Soccer referees apply the rules of the game by closely observing the players. This means that they must keep the pace of the players and move continuously and quickly from one area of the football field to another. For this reason, the referees must undertake a physical training that allows them to keep up with the game and always reach the optimal position to make critical decisions. Thus, the purpose of this study was to determine the effects of the soccer season period on soccer referee's physical performance variables, in soccer referees of different ages.

## Methods

### Procedure

The study was designed to determine the effects of a 28-week period on the results of relevant fitness tests evaluating linear sprint, change of direction and intermittent high-intensity performance in soccer referees during the competitive season 2017/2018. Tests were performed at the start of the pre-season (T0, in September), at the middle of the season (T1, in January) and at the end of the season (T2, in June).

### Participants

Forty-nine soccer referees ($n = 49$ males) that officiated during official soccer matches during the 2017/2018 season volunteered to participate in this study. The age of referees was in the range 16–45 years; thus, participants were classified according to age. The distribution by age was the following: 16–20 years ($n = 17$); 21–29 years ($n = 16$); and 30–45 years ($n = 16$), as detailed in Table 1

According the 2016 FIFA Fitness Tests document, the referees who participated to study, were refereeing at category 1 (Referees who officiate in the professional competitions organized by a professional league), category 2 (Referees who officiate in the semi-professional and amateur competitions organized at national level) and lower categories (Referees who officiate in the competitions organized at regional or provincial level and youth competitions).

All procedures performed were in accordance with the ethical standards of the institutional and national research

**Table 1** Anthropometric data (body mass, height, and % body fat) of the three soccer referees' groups

| Physical characteristics | Mean | SD |
|---|---|---|
| 16–20 years ($n = 17$) | | |
| Age (years) | 20.48 | 5.64 |
| Height (cm) | 176.2 | 4.2 |
| Weight (kg) | 66.5 | 3.1 |
| %Body fat | 13.1 | 0.7 |
| 21–29 years ($n = 16$) | | |
| Age (years) | 23.27 | 1.7 |
| Height (cm) | 180.3 | 2.4 |
| Weight (kg) | 70.2 | 4.8 |
| %Body fat | 13.8 | 1.2 |
| 30–45 years ($n = 16$) | | |
| Age (years) | 35.5 | 4.2 |
| Height (cm) | 179.7 | 3.3 |
| Weight (kg) | 77.2 | 5.2 |
| %Body fat | 14.2 | 3.4 |

committee and with the 2013 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from each participant or from their parents (for minors) after full explanation of the purpose and nature of all procedures used.

## Anthropometric characteristics

The body mass was measured with medical scale (Seca 700, Intermed, Milan) (legalized and standardized to 0.1 kg) and body height was measured in Frankfurt position with height meter attached to digital SECA 220 (Intermed, Milan) within an accuracy of 0.1 cm. The body fat percentage was calculated from four skins fold measurements using a Harpenden caliper (HaB International Ltd., Southam, UK) on the right side of the body [27], as previously described [10]. All measurements were taken at 7.30 a.m. by the same investigator, for all time periods. Anthropometric characteristics of referees, arranged according to age, determined before the beginning of the training period (mean ± SD), are shown in Table 1.

## Training programs

All soccer referees, when healthy, attended a training program formulated by the technical area of the "Associazione Italiana Arbitri". The program consisted at least 3 training sessions per week, including sessions of aerobic-type training (leading to greater performance, high intensity activities), sessions of anaerobic lactic acid type training (speed), sessions of anaerobic lactic acid type training (to promote strength, speed and power) and sessions for the improvement of the muscular strength. In addition, soccer referees have been involved in officiating about 24 matches during the year.

## Physical fitness characteristics

To get information regarding the fitness status of soccer referees we have used tests that have been frequently used by referee governing bodies as part of their match selection criteria: Yo–Yo intermittent recovery test level 1 (YYIRT1) and running speed test.

The YYIRT1 test was developed to measure an athlete's ability to repeatedly perform high-intensity aerobic work. in addition, it has been shown to be a valid and reliable predictor of high-intensity aerobic capacity and $VO_{2max}$ amongst athletes from various sports and competition-levels independently of athlete ages. Finally, the FIFA recommend YYIRT1 as methods of assessing the aerobic fitness of referees with the recommended standards (FIFA refereeing 2019). Then, YYIRT1, as previously described [10] was used as a predictor of high-intensity aerobic capacity and $VO_{2max}$.

Each participant continues running between two parallel lines 20 m apart, at a progressively increasing speeds controlled by the "beeps" on a CD. The subjects had a 10 s recovery period (decelerating and walking back to the starting line) between each running bout. All tests were conducted at the same time of day, carried out in the same order, starting with youngers. Each player was instructed and verbally encouraged to provide maximal effort during all tests.YYIRT1 was also used to estimate $VO_{2max}$ (ml/min/Kg), by the equation of Bangsbo [23]. In the running speed test, the participants performed three maximal 40 m sprints, measured with an infrared photoelectric cell (Speed- trap II Wireless Timing Sistema; Brower Timing System, Draper, UT), as previously described [10].

## The ratings of referees

Ratings are based primarily upon training, experience, performance and fitness by qualified officials on all of the matches assigned. The officials write up a report, which describes the qualities and defects of the colleague and numerically quantifies the performance with a vote. This vote contributes, together with the other votes received by the referee during the season, to the determination of his own average as foreseen by the operating rules of the technical officials of the AIA (Associazione Italiana Arbitri). According to the more recent updates, the evaluation of the referee is based on these aspects: (a) enforcement of the football laws, (b) technical evaluation and disciplinary actions, (c) physical and athletic training, (d) general positioning and movement, (e) referee's aspect, authority and self-control, (f) referee—assistant collaboration, (g) actions to outside interferences.

## Statistic analysis

Data, presented as mean ± SD, were collected in a blinded fashion and analyzed using GRAPHPAD PRISM 5 software (GraphPad Software, La Jolla, CA, USA). The *t* test was used for comparison between data of three groups, composed on the basis of age: (a) 16–20, (b) 21–29 and (c) 30–45 years.

The statistical Friedman's repeated measures analysis of variance by ranks, with Bonferroni-Dunn's correction, was used to estimate the significance levels of the observed differences between the analyzed time points during the whole sporting season.

The Pearson correlation coefficient (*r*) was used to determine the relationships between running speed test, Yo-Yo test performance and measured $VO_{2max}$. The level of statistical significance was set at $p < 0.05$. The Chi-square test

was used to examine the differences in categorical variables between the referees' excellent rating (> 8.5) and younger age.

## Results

### Anthropometric characteristics

Table 1 shows the anthropometric data (body mass, height, and % body fat) of the three soccer referees' groups. These three groups, composed on the basis of age, were (a) 16–20, (b) 21–29 and (c) 30–45 years.

### Physical fitness characteristics

At T0, no significant differences ($p > 0.05$) between groups were detected for the 40 m Sprint test (Fig. 1a); moderate differences ($p = 0.03$) between 21–29 and 30–45 age groups for the YYIRT1 were detected (Fig. 1b). Regarding $VO_{2max}$, significant differences between 30–45 age group and other groups were observed (Fig. 1c).

At T0, 40-m sprint performance were 5.9 ± 0.39 s, 5.78 ± 0.43 s and 5.98 ± 0.23 s, for 16–20, 21–29 and 30–45 age groups, respectively. Significant differences ($p < 0.05$) were noted for 40 m Sprint test in T1 and T2 (Fig. 2).

At T0, the means (± SD) for YYIRT1 were 1629.60 ± 491 m, 1634.54 ± 541 m and 1546.73 ± 567 m, for 16–20, 21–29 and 30–45 years age groups, respectively.

The mean distance covered by the referees during the YYIRT1 increased significantly from T0 to T2, from T0 to T1, and T1 to T2, in the three ages groups (Fig. 3). A significant higher effect was observed for group 16–20 years in all testing periods (Fig. 3a, b).

Finally, at T0, the means (± SD) for $VO_{2max}$ were 50.88 ± 1.35 ml/Kg/min, 50.76 ± 0.79 ml/Kg/min and 50.13 ± 0.75 ml/Kg/min, for 16–20, 21–29 and 30–45 age groups, respectively.

The 16–20 group significantly more improved YYIR1 performance ($p < 0.001$) and $VO_{2max}$ ($p < 0.001$) at T1, but significant differences were also observed in YYIR1 ($p < 0.001$) and $VO_{2max}$ ($p < 0.001$), at T2 (Fig. 4).

Several significant correlations were observed for soccer referees. Precisely, in T2, ages negatively correlated with differences (Δ) of 40 m Sprint test ($r = 0.88$, $p < 0.001$), of YYIRT1 ($r = 0.94$, $p < 0.001$) and $VO_{2max}$ ($r = 0.85$, $p < 0.001$) (Fig. 5a–c).

In the present study, the referees' rating ranged from 8.20 to 8.65. The rating was significantly higher in the younger group (16–20 years) than in the intermediate group (21–29 years, $p < 0.05$) and the older group (30–45 years, $p < 0.001$, by Anova). A positive correlation was found between the excellent rating (> 8.5) and younger age ($p = 0.015$ by Chi-square test $\chi = 8.6$) (Fig. 5d).

## Discussion

The referee of the match must be physically fit to withstand the playing time to make adequate decisions [28]. Thus, the governing boards require the evaluation of soccer referees' physical fitness at the start of the competitive season and set limits for the inclusion in the seasonal match assignation list. From this emerges that soccer referees need a specific physical preparation to be able to carry out the competition course in an optimal way. An exercise training protocol is effective if it induces those adaptations in the organism that determine an improvement in the sporting performance. It follows that a better understanding of the progress of referee physical fitness would help adjust their training protocols. There are few studies that examine the effects of specific training on improving the physical performance of soccer referees. Therefore, the objective of the present work has

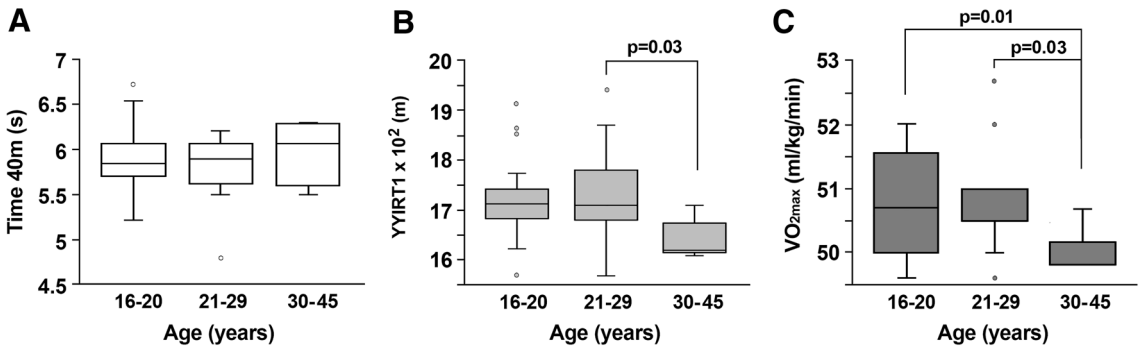


**Fig. 1** Physical parameter in soccer referees. Running speed test (**a**), Yo–Yo intermittent recovery test level 1 (YYIRT1, **b**) and maximal oxygen consumption ($VO_{2max}$) (**c**) were evaluated at the start of the pre-season (T0, in September), in the three different groups. The data are presented as mean ± SD and significant differences between groups were evaluated by *t* test

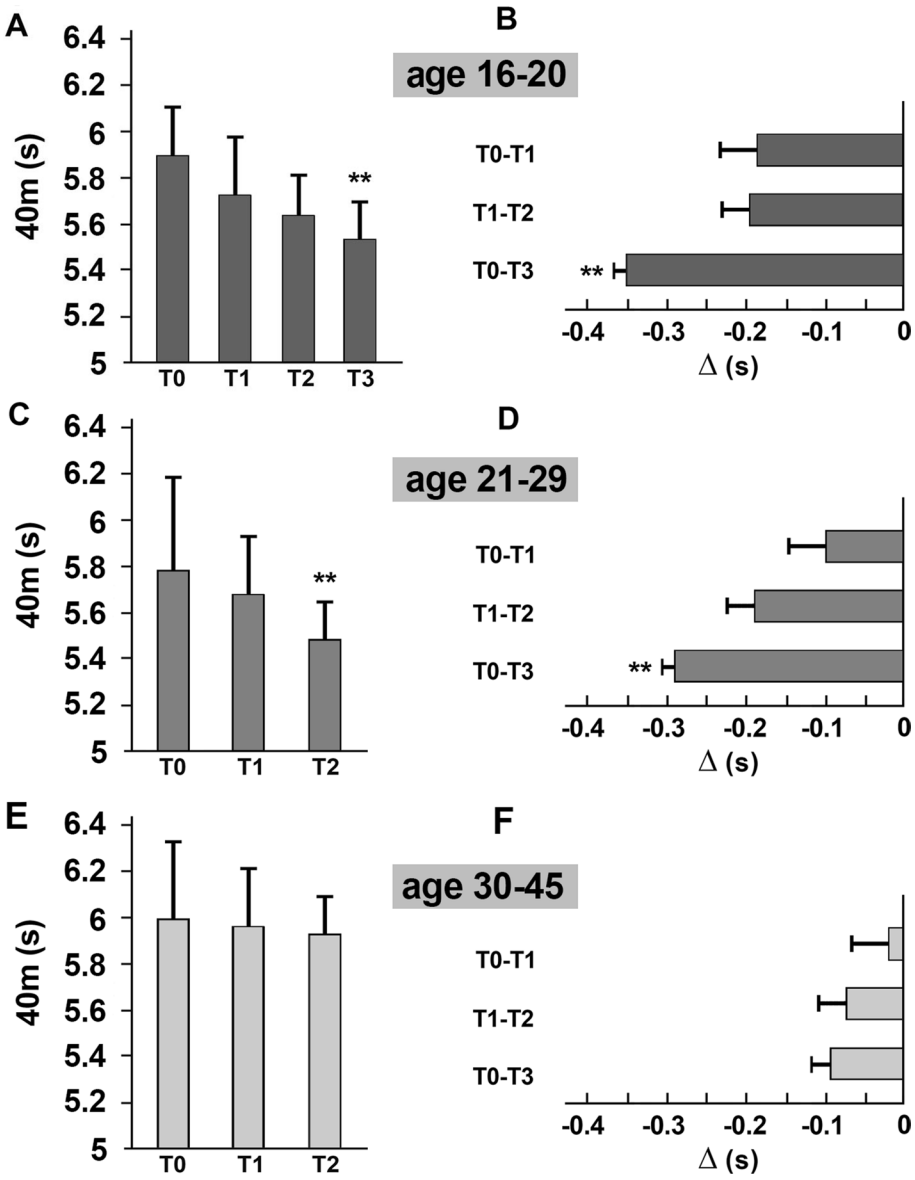


**Fig. 2** Running speed tests and their evolutions during a soccer season follow-up. The soccer referees were classified according to age into three groups: 16–20 (**a**, **b**), 21–29 (**c**, **d**) and 30–45 years (**e**, **f**). **a**, **c**, **e** The soccer referees were evaluated at three different time points: at the start of the pre-season (T0), at the middle of the season (T1) and at the end of the season (T2). **b**, **d**, **f** Differences (Δ) of running speed tests of soccer referees, between each point-time, during a soccer season follow-up, were also evaluated. The data are presented as mean ± SD and significant differences between T1, T2, and T; between T1 and T0, T2 and T1, T2 and T0 were evaluated by *t* test. *$p < 0.05$; **$p < 0.001$, ***$p < 0.0001$

been to examine the effects of the training program formulated by the technical area, athletic preparation section of the "Associazione Italiana Arbitri" on the soccer referees of different ages. Currently, this is the only study that analyzed the variation of the soccer referee physical performance during official championship, taking due account of the age of the referee in interpreting the physical performances. Significant differences in the fitness of football referees were mostly observed at the end of the football season, however young referees performed better in physical performance than adult referees and also obtained better ratings from qualified officers. During a match, a soccer referee covers several meters (mean total distance covered over the period of a whole match 11,376 ± 1604 m [29]) and her/his physical activity is characterized by long, low-intensity activity periods and by frequent brief intense exercise periods [30]. Our results demonstrated that during a football season, following a training protocol that simulated the match demands, that is an intermittent high-intensity training, referees significantly improved their aerobic and anaerobic performance as demonstrated by YYIRT1. In fact, the YYIRT1 has been reported to be highly correlated to referees' match performance [16], since during the test, the aerobic loading is near to maximal values, and the anaerobic system was highly charged [22]. Despite the moderate differences, between age groups for the YYIRT1, detected before the beginning of the soccer season, the group of younger referees reached a higher fitness level, also comparable with football players [10, 22]. In addition to aerobic fitness, repeated sprint performance is also a crucial element of performance athletes [31, 32]. The sprint test and in particular the fastest 40-m time had appropriate construct validity for the physical

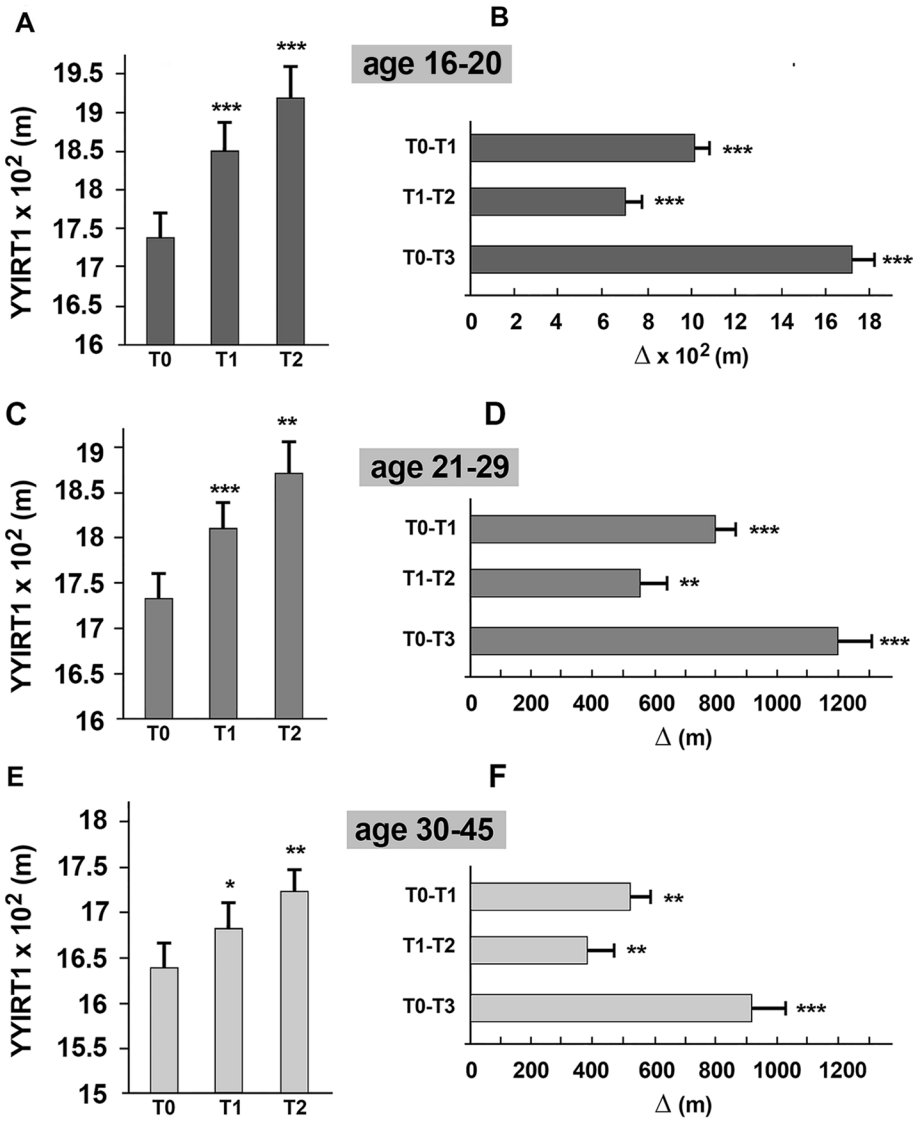


**Fig. 3** Yo–Yo intermittent recovery test level 1 (YYIRT1) and their evolutions during a soccer season follow-up. The soccer referees were classified according to age into three groups: 16–20 (**a**, **b**), 21–29 (**c**, **d**) and 30–45 years (**e**, **f**). **a**, **c**, **e** The soccer referees were evaluated at three different time points: at the start of the pre-season (T0), at the middle of the season (T1) and at the end of the season (T2). **b**, **d**, **f** Differences (Δ) of YYIRT1 of soccer referees, between each point-time, during a soccer season follow-up, were also evaluated. The data are presented as mean ± SD and significant differences between T1, T2, and T; between T1 and T0, T2 and T1, T2 and T0 were evaluated by *t* test. *$p < 0.05$; **$p < 0.001$, ***$p < 0.0001$

assessment of soccer referees [33]. The results demonstrated that the performances improved in 40 m sprint tests. Specifically, these changes were observed between T0 and T2. In addition, younger referees presented a lower sprint time than the other two age categories, at the end of the season.

Regarding the relationship between the sprint test and both aerobic and anaerobic indices, conflicting results were reported. In several studies a higher $VO_{2max}$ appears related to better sprint test performance [34, 35], by allowing the replenishment of phosphocreatine stores during recovery between sprints, thus maintaining performance at high intensity [36]. Other studies reported the $VO_{2max}$ moderately related to sprint test [37, 38]. We found a good correlation and a moderate correlation between $VO_{2max}$ and repeated sprint performance, in 16–20 and 21–29 age groups, respectively. Conversely, no significant differences between groups were detected for the 40 m sprint test no correlation was found between $VO_{2max}$ and sprint test, in the referees aged 30–45 years. On one side, the significant correlations found in younger group indicated that aerobic fitness could be a determinant factor of sprint; however, because of the moderate or inexistent correlation between sprint and aerobic fitness found in the groups of adult (30–45 years), we suggest that additional factors (such as muscle strength and power, and anthropometric features) could be decisive for the repeated sprint performance. During the seasonal follow-up, significant progresses were measured in the physical fitness parameters, both in young (16–29 years) and adult (30–45 years) football referees; however, progresses have been greater in the young referees. It seems quite obvious that aging can have a negative effect on fitness levels [39], however even older referees have worked hard during training, and have thus progressively improved their fitness levels with each test. Therefore, the training sessions performed by soccer referees induced good levels of aerobic and anaerobic fitness levels. These results could also have implications for

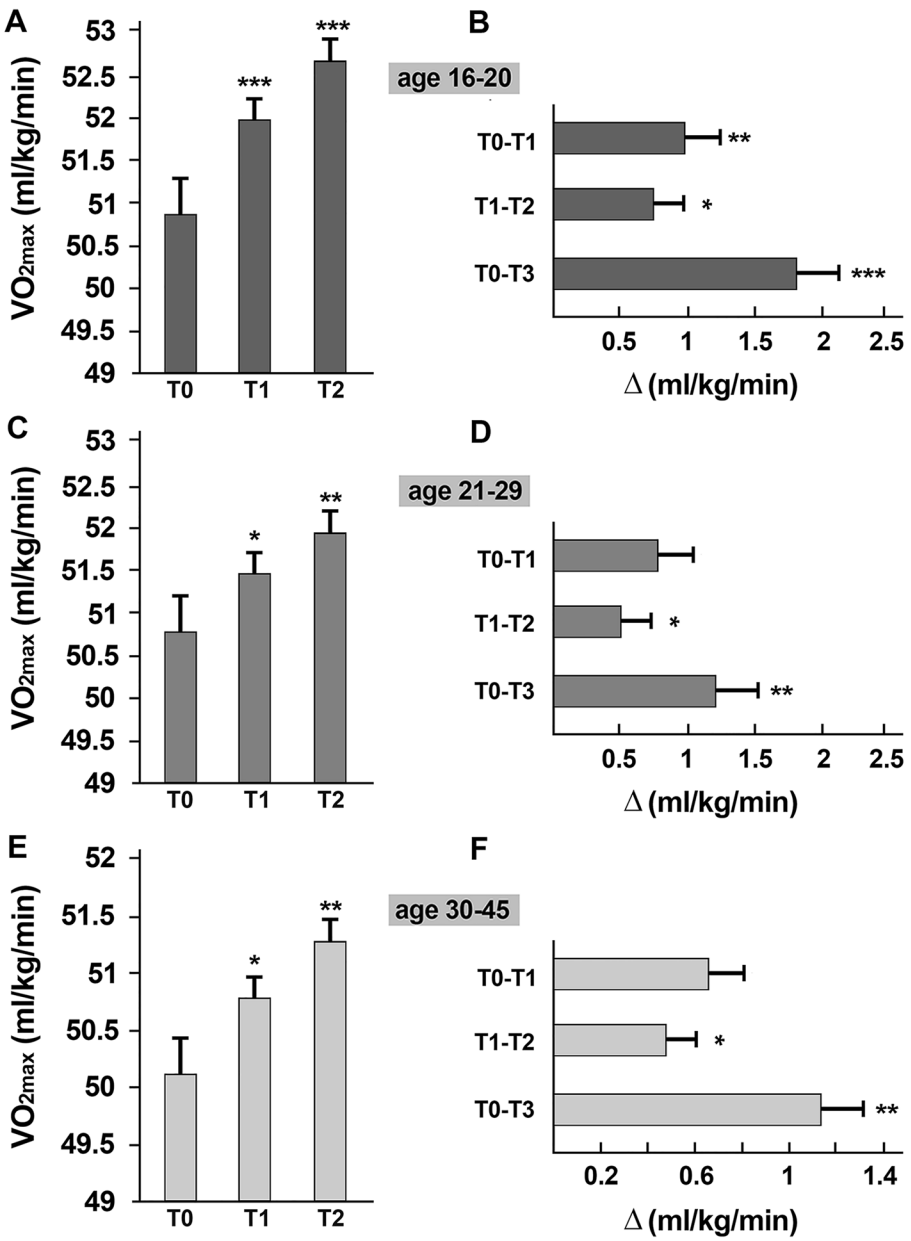


**Fig. 4** Maximal oxygen consumption ($VO_{2max}$) and their evolutions during a soccer season follow-up. The soccer referees were classified according to age into three groups: 16–20 (**a**, **b**), 21–29 (**c**, **d**) and 30–45 years (**e**, **f**). **a**, **c**, **e** Soccer referee's $VO_{2max}$ were evaluated at three different time points: at the start of the pre-season (T0), at the middle of the season (T1) and at the end of the season (T2). **b**, **d**, **f** Differences (Δ) of $VO_{2max}$ of soccer referees, between each point-time, during a soccer season follow-up, were also evaluated. The data are presented as mean ± SD and significant differences between T1, T2, and T; between T1 and T0, T2 and T1, T2 and T0 were evaluated by *t* test. $*p < 0.05$; $**p < 0.001$, $***p < 0.0001$

referees in other sports, because insufficient fitness levels could compromise the referees' capacity to uphold play and thus to correctly referee. The fitness levels in soccer referees correlate with the match performance [16]. In fact, the progress in the referees' fitness, had a great effect on the match performance as demonstrated through the valuation by referee governing bodies as part of their match selection.

In conclusion, it is important to underline that in the literature there are no other reports in which the physical form of young and adult football referees is compared; the data presented here clearly shows that young referees achieve better sports performance than adult referees and achieve higher evaluated by qualified officials.

The main limitation of our study is the small sample size, especially given the high number of matches that are played in the different divisions. In this regard, considerable differences have been reported in the distances covered by the soccer referees between different leagues and in the various playing divisions [40]. Of course, these differences can influence the referees 'physical performances, so further studies are desirable to evaluate the existence of relationships between leagues and referee's activities. Despite an increase in performance in the three age groups analyzed, the young referees get better sports performances and are better evaluated by the qualified officers; thus, we conjecture that the motivation of the young referees could assume a great importance inasmuch as during the adolescence the

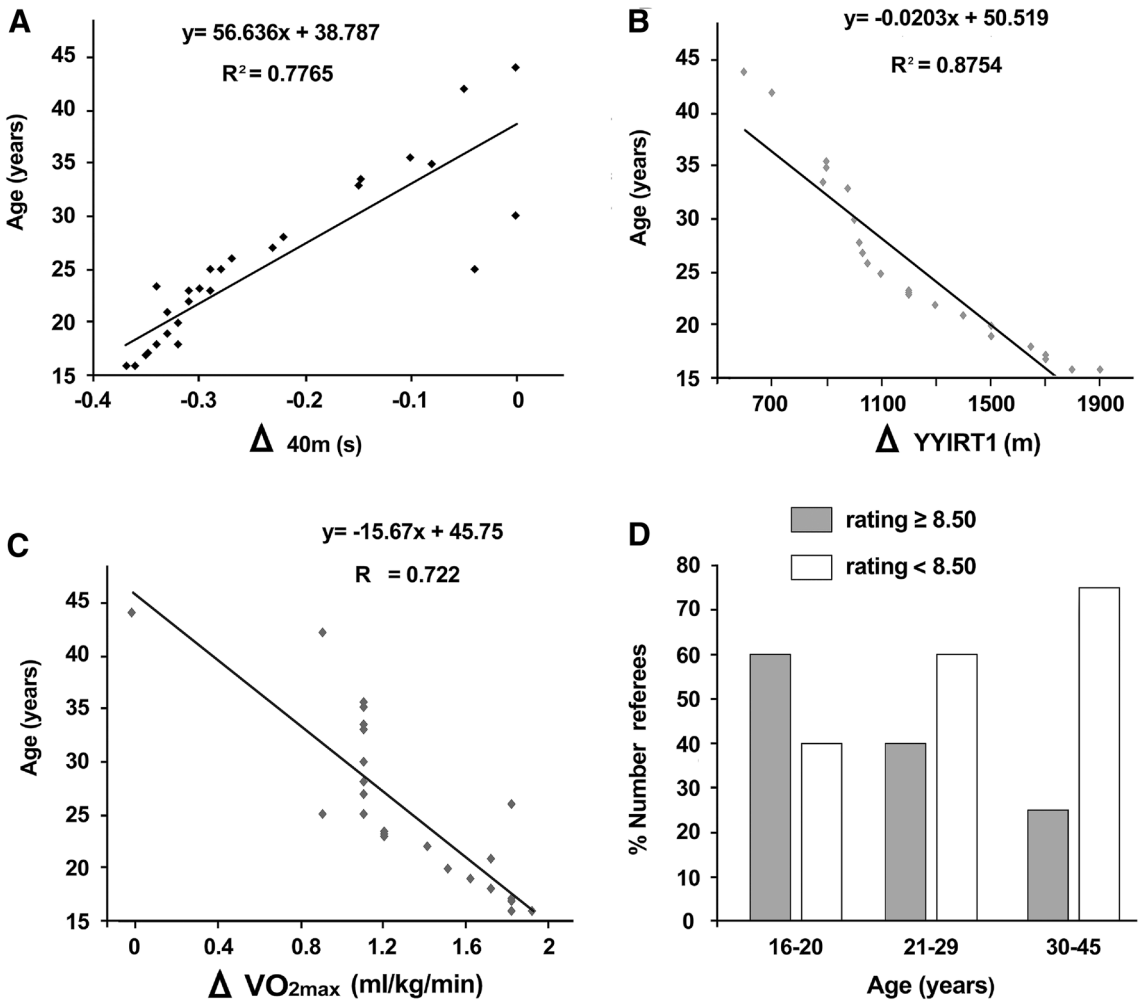


**Fig. 5** Significant correlations. Correlation between ages and differences (Δ) of running speed test ($p < 0.001$) (**a**), of YYIRT1 ($p < 0.001$) (**b**) and $VO_{2max}$ ($p < 0.001$) (**c**). **d** Correlation between the excellent rating (> 8.5) and younger age ($p = 0.015$ by Chi-square test)

referees build the future career. These data also show the need to adjust the training load according to the age of the soccer referees to obtain success in this sport.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no competing interests.

**Ethical approval** All procedures performed were in accordance with the ethical standards of the institutional and national research committee and with the 2013 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** Written informed consent was obtained from each participant or from their parents (for minors) after full explanation of the purpose and nature of all procedures used.

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