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COMPARISON OF PHYSICAL PERFORMANCE AMONG BRAZILIAN ELITE SOCCER PLAYERS OF DIFFERENT AGE-CATEGORIES

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Abstract

Aim. The purpose of this study was to compare the physical performance (*i.e.,* strength, power, speed and endurance) between Brazilian elite soccer players from different categories of the same club: professionals (PRO), under-20 (U-20), and under-17 (U-17).

Methods. Seventy-one soccer players from three categories (PRO=24; U-20=21 and U-17=26) were assessed at the beginning of pre-season. Before the tests, they were familiarized with all experimental procedures. Squat jump (SJ), countermovement jump (CMJ), sprint (10m/20m), maximum dynamic strength (1RM), and Yo-Yo intermittent recovery tests level 1 were performed in three non-consecutive sessions.

Results. No significant differences were found between the categories for sprint times. The PRO players presented higher outcomes in the 1RM, SJ, CMJ, and Yo-Yo tests than the U-20 and U-17 players ($P \leq 0.05$). No significant differences were found between the U-20 and U-17 players in 1RM, and SJ/CMJ heights. The U-20 presented superior performance than the U-17 in the Yo-Yo test ($P \leq 0.05$).

*Conclusion.*The findings indicated that PRO performed better than younger players in all assessments, except for the sprint tests. This may have been possible due to the differences in training experience, technical expertise and individual levels of strength/power. However, the absence of differences between the U-20 and U-17 groups highlighted the necessity of developing specific training strategies in order to improve the physical capacities of younger players, throughout the maturation process. Moreover, due to the importance of sprinting in soccer, it is strongly recommended that fitness coaches develop more effective strategies to improve speed ability in professional players.

Keywords: soccer, strength, power, sprint, endurance

1- Introduction

Soccer is a dynamic sport characterized by short-duration and high-intensity motor-tasks[1]. Soccer players' performance depends on the interaction of many physical capacities, such as strength, power, speed and endurance[1-3]. During an elite soccer match, players run up to 13km[4], which imposes a large stress on the aerobic energy system. In addition, power-related motor activities such as short sprints with/without changes of direction, jumps and kicks are crucial for performance, making the anaerobic energy system activity essential to these athletes[1, 4, 5].

Some researchers have demonstrated that during a soccer match performance in these specific soccer actions is related to players' experience and age[6, 7]. For instance, Mohr *et al.*[7] observed that top elite soccer players (i.e., players from the Italian league, ranked from 1 to 10 on the official FIFA list) covered ~28% more high-intensity running (2.43 vs. 1.9 km) and ~58% more sprinting (650 m vs. 410 m) distance ($P<0.05$) than sub-elite players (i.e., players from the top-Danish league, ranked higher than 20 on the official FIFA list). Lehance *et al.*[6] found higher performance in vertical jumping ability (SJ ≅40 cm vs. ≅35 cm) and sprinting speed time over 10m (≅1.95 s vs. ≅2.05 s) in professional players from the Belgian First Division compared to U-17 soccer players, but no significant differences were found between the PRO and U-21 or between the U-21 and U-17. Similarly, Gissis *et al.* [8] verified, in young soccer players (≅16 years), positive differences in elite players from the National youth team of Greece, when comparing them with sub-elite (who participated in regional championships) and recreational players in isometric force (1282.4N; 1065.4 N; 954.6 N, respectively), vertical jump (SJ = 23.6

cm; 21.4 cm; 20.3 cm, respectively), and 10m sprint time (1.95 s; 2.14 s; 2.21 s, respectively) tests. Taken together, these findings suggest that muscle strength and power capabilities play an important role in soccer performance, since experienced players are able to better execute power-related motor-tasks than sub-elite and younger players.

The abilities required to execute repeated high-intensity actions and perform intermittent non-continuous exercises whilst avoiding excessive fatigue are determinant for successful performance in soccer [9]. It has already been reported that the number of high-intensity actions performed during a match is moderately correlated with performance in the Yo-Yo test (r=0.71) [10]. Thus, it is conceivable that experienced soccer players can cover longer distances than younger players in Yo-Yo intermittent assessments.

In fact, soccer is a very complex sport modality and player performance depends on a wide range of physical and technical capabilities[1, 2, 11, 12]. Additionally, the aging process may induce significant changes in these specific abilities (i.e., strength, power, speed and endurance)[13-18], making it difficult for the technical staff to elect the most adequate training strategy for each specific category. To date, there is a paucity of data reporting the variations in elite soccer players' performance throughout the different age-categories, which may compromise the correct prescription of training methods and loads for each specific age-range. Therefore, the aim of this study was to test for differences in strength, power, speed and endurance performance between elite soccer players from different age-categories: professional (PRO), under 20 years (U-20), and under 17 years (U-17). This information may help head and fitness coaches to program better training strategies in order to elicit positive physiological and neuromuscular adaptations during the players' maturation process.

2- Materials and Methods

Subjects

Seventy-one male Brazilian soccer players from three different categories (i.e., PRO, U-20 and U-17) from the same club participated in this study (Table 1). All players were enrolled in the São Paulo State First Division Championship of their respective category. Evaluations took place at the beginning of pre-season. The number of weekly soccer training sessions performed by each category were PRO = 8 sessions/week and U-20 and U-17 = 5 sessions/week. All players were informed of the experimental risks and signed an informed consent form prior to the investigation. This study was approved by the local ethics committee.

*****INSERT TABLE 1*****

Experimental procedures

This study was designed to compare physical performance (jumping, sprinting, maximum dynamic strength and endurance) of elite soccer players from three different categories. Before all tests standardized warm-up protocols were performed, including general (i.e., running at a moderate pace for 5 mins followed by 3 mins of lower limb light active stretching) and specific exercises. Three minutes after the warm-up, players were required to execute the tests. All participants attended the laboratory for six sessions and prior to the tests, on three non-consecutive days, they were familiarized with all experimental procedures. Body mass and height were measured during the first familiarization session. The experimental sessions were performed on three days, separated by at least 48 hours, in the following order: *day 1* – squat jump and countermovement jump tests; *day 2* – sprint and lower limb maximum dynamic strength tests, and *day 3*- Yo-Yo intermittent recovery test level 1.

Squat Jump and Countermovement Jump Tests

Vertical jump height was evaluated in squat jump (SJ) and countermovement jump (CMJ) tests. Before each test, three submaximal SJ and CMJ were performed. The SJ was performed from an initial static position with 90º knee flexion. Participants were instructed to hold the squat position for 3 seconds before jumping. For CMJ, participants were allowed to freely determine the amplitude of the countermovement in order to avoid changes in jumping coordination [19]. For both tests, players were instructed to keep their hands on their waist during the jump. An experienced researcher conducted the tests and visually checked for countermovement occurrence during the SJ in order to ensure the correct technique. The participants performed five maximal SJ and CMJ with a 15 s interval between attempts and 60 s between the jumping techniques (within-group CV<5%). Jumps were executed on a contact platform (Smartjump System, Fusion Sport, Brisbane, Australia) and vertical jump height was estimated by the flight time, according to the standard procedures proposed by Bosco *et al*.[20]. The best attempt from each jump type was used for data analysis.

10 and 20m sprint test

Three pairs of photocells (Smartspeed System, Fusion Sport, Brisbane, Australia), positioned at 0, 10, and 20m, were used to assess 10 and 20m sprint times. Following a command, players started from a stationary standing position, sprinting as fast as possible, until the last pair of photocells. Two 20m trials, separated by a 60 s rest interval were performed by each player. Before the trials, two submaximal 20m attempts were performed. The best trial was used for statistical analysis.

Maximum dynamic strength in the squat exercise

Maximum dynamic strength in the squat exercise was measured through the one repetition maximum test (1RM) performed on a Smith machine (Technogym Equipment, Cesena, Italy). Before the test, all players performed two specific warm-up sets. In the first set, they performed 8 repetitions with 50% of their estimated 1RM; in the second set, they performed 3 repetitions with 70% of their estimated 1RM. A 2 min rest interval was allowed between sets. Three minutes after the warm-up, participants were requested to execute up to 5 attempts to obtain their squat exercise 1RM load (e.g., maximum weight that could be lifted once with a proper technique) with a 3 min rest interval between attempts[21]. In addition, relative strength was calculated by dividing the 1RM value by the player's body mass (BM) (1RM/BM).

The Yo-Yo intermittent recovery test level 1

The Yo-Yo intermittent recovery test level 1 was performed according to the procedures suggested by Castagna *et al*.[22]. All players were familiarized with the testing procedures. Prior to the assessments, all subjects carried out a specific warm-up, comprising four submaximal running bouts, similar to those performed in the actual tests. The Yo-Yo intermittent recovery test level 1 consisted of repeated 2 x 20m runs performed at increasing speeds with a 10 second active recovery (2 x 5-m jogging) between runs, until exhaustion. An audio beep reproduced by a CD player determined the Yo-Yo test rhythm. The test ended when the participant failed twice consecutively to follow the pre-determined test rhythm or when the participant felt unable to complete another shuttle run at the dictated speed. The total distance covered during the test (including the last incomplete shuttle) was considered as the test score. The test was performed in an indoor gym on a wooden surface with the test distance (20m) being delimited by cones.

Statistical Analyses

Data are presented as mean ± standard deviation (SD). Normality was confirmed through visual inspection and the Shapiro-Wilk test. One-way mixed model analysis was used to test for differences between the three groups for all dependent variables. When F ratios were significant, a post-hoc analysis with Scheffe´s adjustment for multiple comparison tests was performed. A high level of reliability was observed in the jump, sprint and maximum dynamic strength tests (ICC: SJ = 0.93; CMJ = 0.96; 20m sprint test = 0.88 and strength test = 0.94).The level of significance was set at $P \leq 0.05$. Effect size (ES) for all dependent variables were calculated according to the previously described method [23].

3- Results

No significant differences were found between the three groups for the 10 and 20m sprint tests (ES = 0.13, 0.3 and 0.14 for U-20 vs. U-17, PRO vs. U-17, and PRO vs. U-20 for 10m, respectively; ES = 0.6 between U-20 vs. U-17; ES = 0.21 between PRO vs. U-17; ES = -0.38 between PRO vs. U-20 for 20m) (Figure 1). The PRO players presented higher values in the 1RM, 1RM/BW, CMJ and SJ than the U-20 (ES =2.9; 1.87; 0.66; 0.68, respectively) and U-17 players (ES = 2.42; 1.35; 0.67; 0.82, respectively). No significant differences were found between U-20 and U-17 players for 1RM, 1RM/BW, CMJ and SJ (ES = -0.55; -0.6; -0.03; 0.002, respectively) ($P \leq 0.05$) (Figures 2 and 3). The PRO players also presented higher values in the Yo-Yo test than the U-20 (ES = 0.66) and U-17 (ES = 1.21) ($P \leq 0.05$), and the U-20 presented higher values than the U-17 (ES = 0.77) ($P \leq 0.05$) (Figure 4).

*****INSERT FIGURE 1*****

*****INSERT FIGURE 2*****

*****INSERT FIGURE 3*****

*****INSERT FIGURE 4*****

4- Discussion

The purpose of this study was to compare strength, power, speed and endurance performance between different age-categories of elite soccer players. We observed that: *a)* there was no statistical difference ($P \geq 0.05$) between the three groups in 10 and 20m sprint times; *b)* the PRO group performed better in absolute and relative maximum dynamic strength (1RM and 1RM/BM, respectively), and vertical jumping performance (CMJ and SJ heights) than the U-20 and U-17 players ($P \leq 0.05$); *c)* there were no significant differences ($P \leq 0.05$) between the U-20 and U-17 groups in 1RM, 1RM/BM, CMJ and SJ performance; and *d)* the PRO group covered significantly longer distances than the U-20 and U-17 groups in the Yo-Yo intermittent test, as well as the U-20 compared to the U-17 ($P \leq 0.05$).

Few studies have compared physical performance between elite soccer players from different age-categories[6, 24]. Lehance *et al.*[6] compared PRO, U-21, and U-17 players from the Belgian First Division. The authors reported significantly higher performances in SJ and 10m sprint tests in the PRO compared to the U-17 soccer players, but no significant differences were found between the PRO and U-21, and between the U-21 and U-17 athletes. In addition, no significant differences in relative strength performance (i.e., isokinetic tests normalized by body mass) were observed between the categories. Our results disagree with those reported by Lehance *et al.*[6], since the PRO players performed better than the U-20 and U-17 in absolute and relative strength in the squat exercise. In part, the higher values of dynamic muscle strength presented by the PRO group may be attributed to their wide experience in elite performance training, which commonly contains higher volumes/frequency of strength/power training sessions.

Furthermore, it is likely that the maturation process favors the neuromuscular and structural adaptations in this specific group of athletes, especially during the transition phase from the younger (U-20 and U-17) to PRO categories. There is a consistent data base indicating the physical superiority of younger athletes when compared to non athletes of the same chronological age [25-27]. To some extent, the increases in strength and power abilities in young athletes during the maturation process may be associated with the increases in muscle cross-sectional area (arising from the training process), and its direct relationship with force production [28]. Thus, it is possible that the U-17 players had greater similarities related to the maturation process with the U-20 subjects, who were naturally more advanced in this biological process. As a result, any change in performance after the maturation process would be due to training, not the maturation aspect.

Strong/moderate relationships between vertical jumping ability and maximal strength performance have been widely reported in soccer[3,29]. Since PRO players performed better in the 1RM tests, we expected that they would jump higher than the U-17 and U-20 groups in the SJ and CMJ attempts. The study results confirmed our expectations with the PRO group presenting superior performance to the younger categories (U-17 and U-20) in both vertical jump assessments. Another study [6] reported similar differences in SJ height between PRO and U-17 players (≅40 cm vs. ≅35 cm, respectively). In this research, the authors speculated that the difference could be explained by the absence of specific power/plyometric training in the U-17 category. Our findings showed no significant differences in strength and vertical jump performance between the U-20 and U-17 groups, which may be explained by the similarity in frequency/volume of soccer-specific training (5-sessions/week) and the absence of a regular program of power exercises and/or plyometrics in both categories. It is important to emphasize that vertical jumping ability has already been related to *"team success rate"* (defined as final league standing among a series of elite soccer teams) in a prospective study involving 17 professional clubs from the Icelandic first division[30], Arnason *et al.* [30] reported a significant relationship between the team average for CMJ and standing jump height and team success in the final standings of teams in a championship. It is important to note that even though CMJ and standing jump heights per se are not responsible for soccer performance, they are directly related to lower limb muscle power, and thus it is conceivable that athletes with higher CMJ and SJ heights may be able to perform soccer skills at superior levels of expertise. As the U-20 and U-17 groups presented similar performances in the SJ and CMJ tests, it is highly recommended that fitness coaches working with these athletes pay more attention to plyometrics, by programming specific training strategies to enhance vertical jumping ability in younger categories. This early intervention could increase the capacity of the players to jump higher, thus enhancing their chance of a successful career in professional/elite soccer.

As well as vertical jumping ability, the capacity to sprint faster has been associated with maximum muscle strength in soccer players[3, 29]. For instance, Wisloff *et al.*[3] observed a strong correlation between half-squat 1RM and 10m sprint time (r=-0.94), whereas Comfort *et al.*[29] showed a moderate correlation between predicted squat 1RM and 20m sprint time (r=-0.64). Surprisingly, despite the higher values of 1RM presented by the PRO players, we did not observe significant differences between the age-categories in sprint performance. In agreement, previous studies involving others team sports such as handball [31], rugby [32], and basketball [33] also did not observe differences in sprint performance between players from different age-categories. Possibly, sprint ability is not essential to determine the *level of expertise* in team sports, and other factors, such as technical and/or tactical abilities may have a more important influence on specific athletes' performance. Nevertheless, the absence of differences in sprinting speed between the PRO and younger groups should be viewed with caution. A recent study published by Barnes *et al.*[11] showed a linear increase in high-intensity running over very short distances, across 2006/2007 and 2012/2013. This analysis reports an increased number of short-sprints during a match, with a concomitant enhancement in the maximal sprint velocity (9.12 ± 0.43 to

9.55 ± 0.40 m.s^{-1}). It emphasizes the necessity to develop better strategies for improving speed ability throughout the maturation process of elite soccer players.

Regarding endurance ability, Ekblon*et al.*[9] observed that intermittent intensive efforts are highly predominant during a soccer match. Additionally, Krustrup *et al.*[10] reported significant correlations between the Yo-Yo test and the number of high-intensity actions (r=0.71), number of sprints (r=0.58), and total distance covered (r=0.53) during a soccer match. Our results indicated that the Yo-Yo test score improved as age increased (U-17<U-20<PRO). These results could be explained by the long-term physiological adaptations provided by specific soccer training and/or the maturation process during aging from the U-17 to the PRO categories. Similar results were found by Markovic and Mikulic[14], who observed an improvement in Yo-Yo test performance with age (i.e., U-13, U-14, U-15, U-16, U-17, U-18, and U-19). This information demonstrated that the Yo-Yo intermittent recovery test level is a valid indicator of endurance performance among multiple soccer age-categories.

5- Conclusion

To conclude, the results reported herein demonstrate that professional soccer players have higher levels of strength, power and endurance than U-20 and U-17 players, whereas U-20 players perform better than U-17 in the Yo-Yo intermittent recovery test level 1**.** The lack of differences in vertical jumping ability between the U-20 and U-17 groups highlights the necessity of developing specific programs to increase lower limb muscle power in these respective groups of young athletes. Since the sprint times did not differ between professional and young players, it is suggested that new methods of speed training (i.e., resisted sprint, overspeed, and combined speed training) be incorporated into the PRO training routine, in order to improve their sprinting performance. The fact that endurance increased gradually throughout the age-categories indicates that the maturation process may be beneficial to this capacity. It may be related to the inherent factors of players' aging and the predominance of the aerobic metabolism in specific soccer training and matches. Given this data and considering the importance of neuromuscular performance in elite soccer from different age-categories, it is reasonable to enhance the frequency/volume/intensity of strength-power training and plyometrics progressively, as the soccer players mature, which may be important for increasing a player's possibility of achieving a prominent career in this sport. Further studies should be developed in order to study the chronic adaptations of these specific modes of training in different age-categories, and the potential effects that these adaptations may have on the technical aspects of soccer performance. From a practical point of view, it is important to reinforce the use of a wide range of strength-power training methods and tests in all soccer age-categories. This practice is crucial for improving the players' performance, eliciting important neuromuscular adaptations throughout the maturation process and even in professional categories. Conversely, it appears that endurance capacity may be improved without adopting a specific endurance training strategy, but instead, through the occurrence of the aging process and the systematic repetition of soccer specific training.

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TABLES AND FIGURES LEGENDS

Table 1. Characteristics of the Soccer players (mean ± SD).

Figure 1.Panel A – 10m sprint time (seconds, mean ± SD) for under-17 (U-17), under-20 (U-20), and professional (PRO) groups. Panel B – 20m sprint time (seconds, mean ±SD) for U-17, U-20, and PRO groups.

Figure 2. Panel A - Maximal dynamic strength (kilograms, mean ± SD) in the squat exercise for under-17 (U-17), under-20 (U-20), and professional (PRO) groups. Panel B – Relative strength per body weight (1RM/BM, mean ± SD) for U-17, U-20, and PRO groups. *$P \leq 0.05$ greater than the other groups.

Figure 3. Panel A – Countermovement jump height (centimeters, mean ± SD) for under-17 (U-17), under-20 (U-20), and professional (PRO) groups. Panel B – Squat jump height (centimeters, mean ± SD) for under-17 (U-17), under-20 (U-20), and professional (PRO) groups. *$P \leq 0.05$ greater than the other groups.

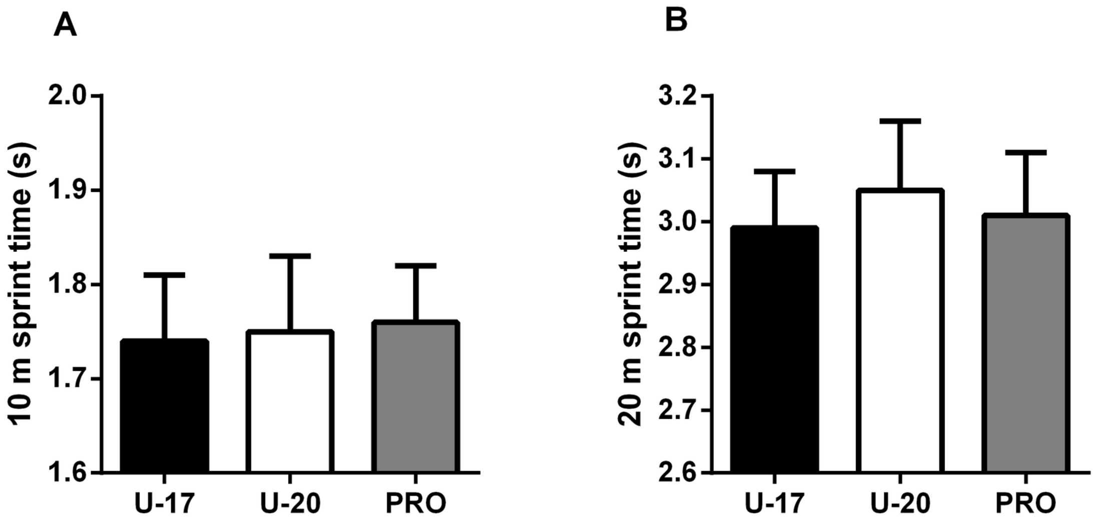
Figure 4. Yo-Yo intermittent recovery test level 1 (meters, means ± SD) for the under-17 (U-17), under-20 (U-20), and professional (PRO) groups. #$P \leq 0.05$ greater than the U-17. *$P \leq 0.05$ greater than the U-20.

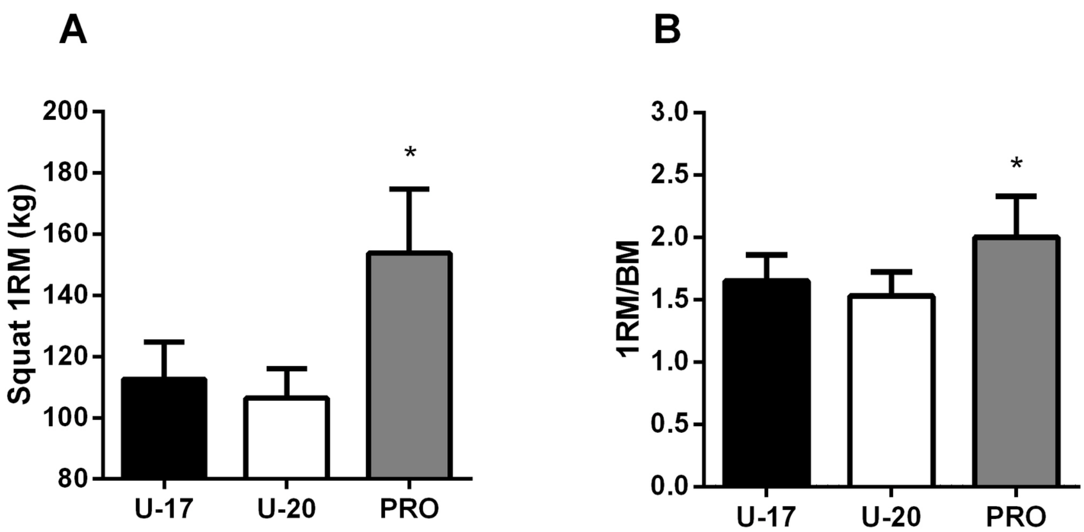
Table:

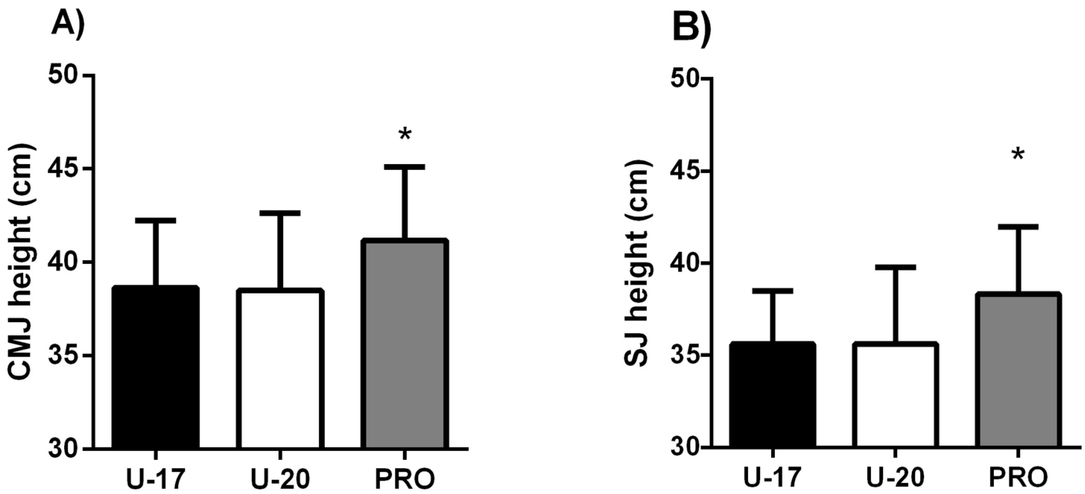
Table I – Soccer players characteristics (mean ± SD)

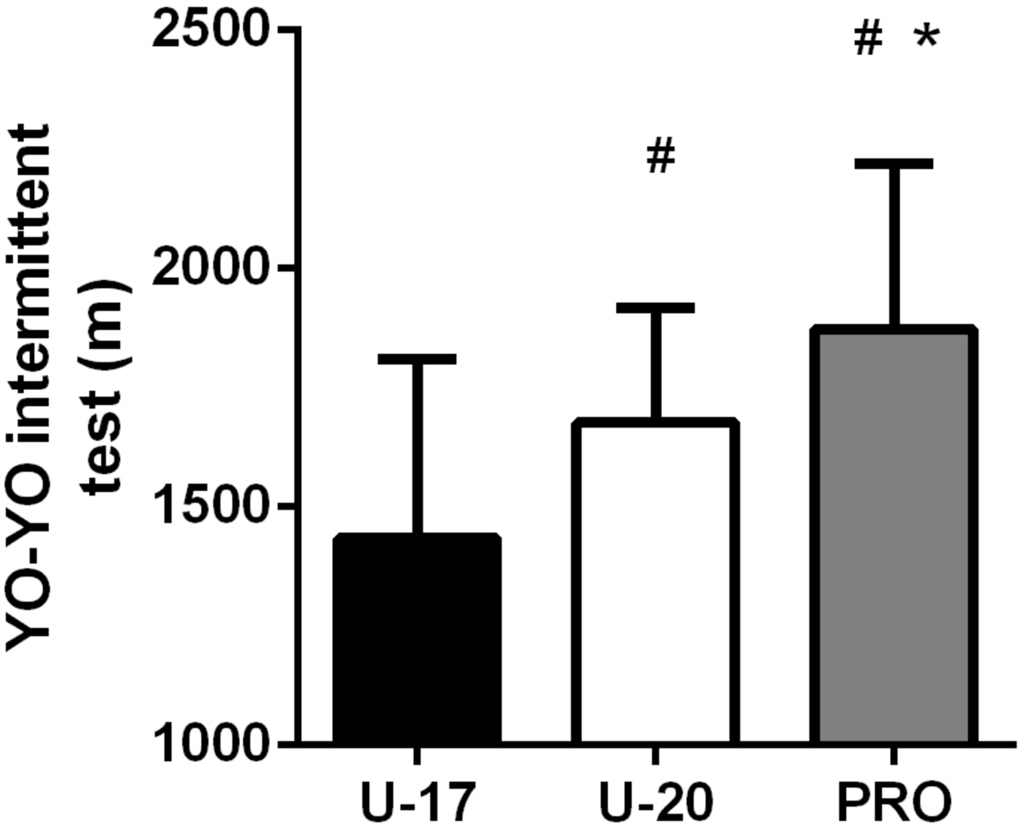
	U-17 (n=26)	U-20 (n=21)	PRO (n=24)
Age (yrs)	16 ± 0.4	19 ± 0.6	22 ± 2.9
Height (cm)	172 ± 6.0	176 ± 7.5	180.3 ± 6.2
Body mass (kg)	68.8 ± 7.5	69.8 ± 5.8	77.6 ± 7.0#*
Training experience (yrs)	4.4 ± 1.0	6.6 ± 1.5#	9.1 ± 1.7#*

*greater than the U-20 (P ≤ 0.05); # greater than the U-17 (P ≤ 0.05)


A
2.0
1.9
1.8
1.7
1.6
10 m sprint time (s)
U-17
U-20
PRO
B
3.2
3.1
3.0
2.9
2.8
2.7
2.6
20 m sprint time (s)
U-17
U-20
PRO


A
Squat 1RM (kg)
200
180
160
140
120
100
80
*
U-17
U-20
PRO
B
1RM/BM
3.0
2.5
2.0
1.5
1.0
0.5
0.0
*
U-17
U-20
PRO


A)
CMJ height (cm)
50
45
40
35
30
*
U-17
U-20
PRO
B)
SJ height (cm)
50
45
40
35
30
*
U-17
U-20
PRO


YO-YO intermittent test (m)
2500
2000
1500
1000
#
*
U-17
U-20
PRO