BMC Sports Science, Medicine and Rehabilitation

RESEARCH

Open Access

Comparisons of the anthropometric and physical characteristics of young elite Chinese male soccer players by age and playing position

Zhe Sun[1], Xin Liu[1], Honghao Fu[2], Shaoshuai Shen[3] and Xiao Zhou[2*]

Abstract

This study aimed to compare the anthropometric and physical characteristics of elite 15-, 16-, and 17-year-old male soccer players by playing position. We recruited 238 players under 17 years of age from Chinese professional soccer clubs. The measurements included body height and mass, body girth and length, and body composition. The countermovement jump (CMJ), T-test, and Yo-Yo intermittent recovery test level 1 (YYIR1) were used to assess physical ability. The results revealed that the U16 and U17 players had significantly greater body mass ($p < 0.05$), body height ($p < 0.05$), muscle mass ($p < 0.05$), lower limb length ($p < 0.05$), and chest girth ($p < 0.05$) than did the U15 players. Significant differences in calf girth ($p < 0.001$), thigh girth ($p < 0.05$), and Achilles tendon length ($p < 0.05$) were observed between the U17 group and U15 group. Additionally, the U16 group and U17 group both scored significantly better than the U15 group on the 5-m sprinting test, 20-m sprinting test, 30-m sprinting test ($p < 0.001$), single left jump test *with arm swing* ($p < 0.001$), single right jump test *with arm swing* ($p < 0.001$), T-test ($p < 0.001$), CMJ test ($p < 0.001$), and YYIR test ($p < 0.001$). Furthermore, U17 players performed significantly better on the CMJ test ($p < 0.001$) and YYIR test ($p < 0.001$) than U16 players did. This study revealed significant differences in body height, body mass, muscle mass, chest girth, lower limb length, ankle circumference, calf length, Achilles tendon length, 20-m speed, 30-m speed, and YYIR test results among the six playing position groups. Goalkeepers and central defenders had significantly greater body heights than players at other playing positions. Goalkeepers scored significantly lower on the YYIR test than players in other positions did. These findings revealed the anthropometric and physical characteristics of elite 15-17-year-old male soccer players in China, helping soccer coaches better understand the anthropometric and physical characteristics across ages and playing positions when selecting youth soccer players and optimizing soccer training programs. Moreover, youth soccer players can gain insights into their own strengths and weaknesses, enabling them to develop training for personal improvement.

Keywords Soccer players, Age categories, Playing positions, Anthropometric, Physical fitness

*Correspondence:
Xiao Zhou
syuu@hust.edu.cn
[1]Chengdu Sport University, Chengdu, China
[2]School of Physical Education, Huazhong University of Science and Technology, Wuhan, China
[3]School of Education and Welfare, Aichi Prefectural University, Nagakute, Aichi, Japan

Introduction

The anthropometric and physical characteristics of soccer players from different regions of China differ [1]. Soccer requires players to accelerate, decelerate, and change direction to evade opponents, with repeated sprinting and jumping during match play. Owing to the special characteristics of soccer, anthropometric and physical characteristics are seen as key factors for performance and ideal playing positions [2–5].

Some studies have established anthropometric and physical parameters (e.g., percentage of body fat, 15-m sprinting, and Yo-Yo intermittent recovery (YYIR) tests) for identifying elite youth soccer players [6, 7]. There are significant differences in anthropometric and physical characteristics among soccer players of different ages (middle to late adolescence). Moreover, several anthropometric and physical parameters can be used to effectively screen elite athletes from nonelite athletes [6, 7]. For example, elite youth soccer players were found to be leaner than nonelite and unsuccessful players were, and muscle mass differed significantly among the players [8]. In terms of anthropometric and physical parameters, significant differences in physical performance were found with the maturation process [9, 10]. For example, the body height, body weight, percent body fat, and lean body mass of the older soccer players were greater than those of the younger age groups, and the increases in body height, body weight, and lean body mass between the older and younger age groups correlate with the physical development normally observed postpuberty [9]. It was also found that the older the age groups, the better the performance (jumping, sprinting, and change of direction) [10]. However, with respect to body fat mass, some previous studies reported that the percentage of body fat mass tends to decrease with age [11] while other studies reported that the association between age and the percentage of body fat mass is unclear [12].

With respect to the position-specific fitness characteristics of soccer players, previous studies have shown that agility, endurance, sprinting, lower limb strength, and anaerobic fitness differ across various positions [13, 14]. In contrast, a previous study reported that playing position had no influence on agility (change of direction (COD) test), lower limb strength (countermovement jump (CMJ) test), sprinting speed, or anaerobic fitness [10]. With increasing age, playing position should also be included in the analysis of young soccer players' characteristics. Despite the emergence of studies on different age groups and playing positions, the differences among youth soccer players with various playing positions are still unclear. Given this, investigating the anthropometric and physical characteristics among various ages and playing positions is meaningful. Nonetheless, no studies on anthropometric and physical characteristics among youth elite Chinese soccer players were found.

On the basis of the above information, this study aimed to (1) analyze variations in anthropometric and physical characteristics among age groups (15-, 16-, and 17-year-old soccer players) and (2) explore the anthropometric and physical differences among various playing positions (goalkeeper (GK), central defender (CD), external defender (ED), central midfielder (CM), external midfielder (EM), and forward (FW)) among young elite Chinese male soccer players. Based on the previous studies, we hypothesized that significant differences in anthropometric and physical characteristics existed among the participants broken down by age and playing position.

Materials and methods

Inclusion and exclusion criteria

The inclusion criteria were male soccer players aged 15-17 years and individuals who were active players at the elite level. The exclusion criteria included youth soccer players who refused to participate in this study and players who had been injured in the past month and were unable to complete the performance measures.

Participants

A total of 238 elite male soccer players aged 15-17 years were recruited from Chinese professional soccer clubs and provincial soccer associations. The players aged 15 years ($n = 87$) were allocated to the U15 group, the players aged 16 years ($n = 99$) were allocated to the U16 group, and the players aged 17 years ($n = 52$) were allocated to the U17 group. Participants in the U15, U16, and U17 groups had at least 3, 4, and 5 years of experience in soccer training, respectively. They trained an average of 4 days per week (80 min per session) and participated in one official match (90 min). The players were also divided into 6 groups according to position: the GK group ($n = 20$), CD group ($n = 41$), ED group ($n = 48$), CM group ($n = 44$), EM group ($n = 65$), and FW group ($n = 20$). All players were performing at a national tournament level and participated in all tests without injuries. A priori power analysis was conducted to calculate the sample size via G*power 3.1.9.2. For one-way analysis of variance (ANOVA), a minimum sample size of 156 participants was necessary to detect significant differences in the means of the physical characteristics of the three age groups, with the effect size calculated on the basis of the previous review (effect size = 0.29; power = 90%; two-tail α of 0.05) [15].

Anthropometric measurements and physical performance tests were performed to collect the data of all the participants. The tests were performed in five cities of China (Weifang, Hangzhou, Wuhan, Beihai, and

Beijing) in the midseason period (September–November) of 2022. All participants were asked to maintain a regular diet during the testing week, fast for at least two hours before the test, and refrain from using depressants (e.g., alcohol) or any known stimulants (e.g., caffeine) for 24 h prior to the test. Prior to the measurement, the athlete had not undergone any training and had already defecated and urinated. To reduce measurement errors due to factors such as temperature and diet time, the anthropometric measurements were performed between 09:00 and 11:00 in the morning, and the physical performance tests were performed between 14:00 and 17:00 in the afternoon. The examiners included four PhD students and six sports science master's degree students who were uniformly trained before the experiment. All the examiners were familiar with the test process and had mastered all the test methods. To examine reliability between the examiners, coefficients of variation (CV) were all tested and showed high reliability (CV < = 3.47%). Before the test, the measurement equipment was unified and standardized, and it was strictly inspected and calibrated.

The study design, protocol, and risk were well known to the players and their legal guardians. This study was reviewed and approved by the Institutional Ethics Board of Tongji Medical College, Huazhong University of Science and Technology, China (Notification Number [2023] IEC (S172)). This study followed the ethical principles of the Helsinki Declaration for human research. Written informed consent forms were obtained from all the participants and guardians of the minors.

Anthropometric measurements

All the players' anthropometric characteristics were measured. Body height (BH) was measured to the nearest 0.1 cm using a portable stadiometer (Seca 217, Hamburg, Germany). Body mass (BM) was measured with an accuracy of 0.1 kg. Chest girth, calf girth, ankle circumference, and thigh circumference were measured with an accuracy of 0.1 cm (circumference ruler, Donghuateng Sports Apparatus Ltd., Beijing, China), as were the lower limb length, Achilles tendon length, arm length, and finger distance (Martin ruler, Donghuateng Sports Apparatus Ltd., Beijing, China). Body composition (e.g., fat mass, body fat, etc.) was measured with an Inbody 770 (Biospace Co., Ltd., Seoul, Korea) (intraclass correlation coefficients ≥ 0.98) [16]. A third measurement was taken if there was more than a 5% difference between the first two measurements.

Physical performance tests

It was ensured that the number of participants in each test group was equal to the number of examiners, allowing for individual measurements of participants during the tests. Players participated in the T-test after completing the Fédération Internationale de Football Association (FIFA) 11 + warm-up activities as a group for 3 min. The testing schedule ensured that all participants had a 3-minute interval between the T-test and the 30 m sprint test, between the 30 m sprint test and the CMJ test, and between the SLJ test and the Yo-Yo IR test. The interval between the CMJ test and the SLG test was 5 min. To ensure that the participants could recover adequately, all the participants to have time intervals between each trial of all the tests. The time intervals were as follows: (1) 30 s between each trial of the T-test, (2) 3 min between each trial of the 30-metre sprinting test, (3) 1 min between each trial of the CMJ test, and (4) 1 min between each trail of the SLJ test. The experimental protocol is shown in Fig. 1.

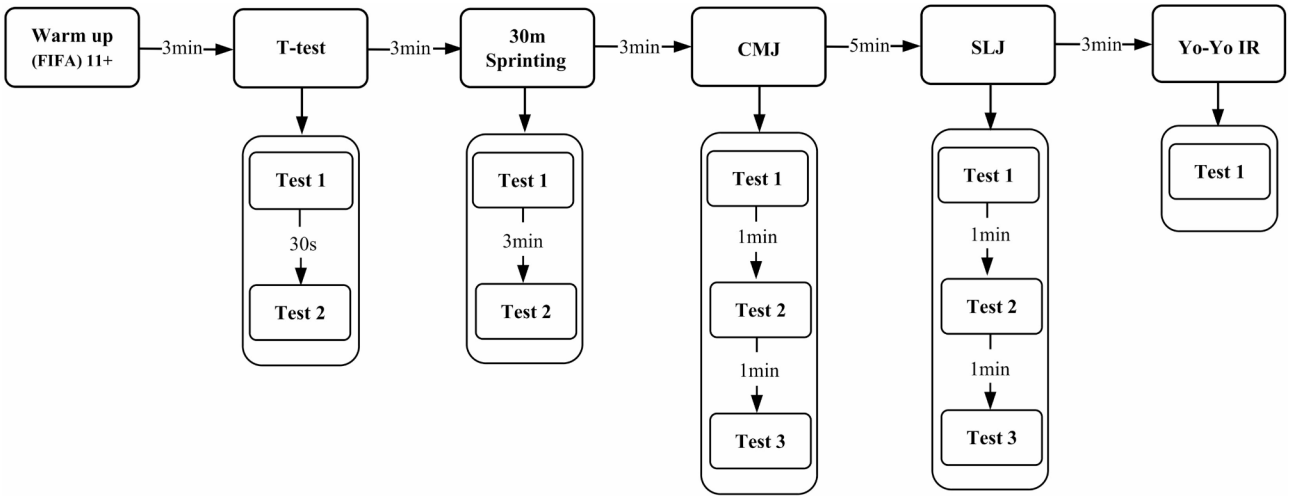

Fig. 1 Experiment protocol

Sprinting performance

As in a previous study, a 30-m sprinting test was performed on artificial turf using a photoelectric cell timing gate system (Smartspeed Pro, Fusion Sport, Brisbane, QLD, Australia) [17]. The gates were placed at 5 m, 10 m, 20 m, and 30 m, and the time the participants passed through each gate was recorded. The standing participants were concentrating on the light start signal that would be shown 5 m from the first timing gate. As soon as they saw the signal, they sprinted at maximum speed while wearing soccer shoes. Strong verbal encouragement was provided to each participant during the test. All the participants were asked to sprint for 30 m before slowing down. Each participant had two attempts and three minutes for recovery between the two tests. Finally, the shortest sprinting time was selected.

Jumping performance

The CMJ and single leg jump (SLJ) test were performed via a multifunctional jumping mat system (SmartJump, Fusion Sport, Brisbane, QLD, Australia) to evaluate the players' jumping ability. The participants were instructed to stand on the platform (wearing shoes) in an upright position and then squatted to a self-selected depth prior to jumping vertically as explosively as possible; the players' hands were fixed at the hips at all times during the CMJ test [18]. The participants had three attempts with 1 min of recovery time between attempts. In the SLJ test, the participants stood in an upright position and then squatted to a self-selected depth prior to jumping vertically with one leg; the participants' hands hung freely, and they landed on the same leg. Three tests were performed for each leg, and the recovery time between attempts was 1 min. A five-minute rest interval was allowed between the CMJ and SLJ tests for fatigue prevention. Finally, the best result (height) was selected for the data analysis.

T-test

A T-test was used to evaluate the players' agility via rapid movements performed on artificial soccer turf [19]. In this test, participants started with both feet behind the starting line A. Each participant sprinted forward to cone B and touched its base with their right hand. Facing forward and without crossing their feet, they shuffled left to cone C and touched its base with their left hand. They then shuffled right to cone D and touched its base with their right hand, shuffled back left to cone B and touched its base, and finally ran backward as fast as possible to return to line A. (Fig. 2). The modified measurement has been shown to be reliable and has an intraclass correlation coefficient greater than 0.9 [20]. The best measurement of the two tests was recorded via a photoelectric cell timing gate system (Smartspeed Pro, Fusion Sport, Brisbane, QLD, Australia).

Yo-Yo intermittent recovery test level 1 (Yo-Yo IR1)

The participants repeatedly ran back and forth between the starting and turning lines in the Yo-Yo IR1 until they became fatigued [21]. The speed was controlled by an audio beeps signal while running in a twenty-meter shuttle area, and the players actively recovered by jogging within 10 s before each run in the recovery area. The participants' running distance during the Yo-Yo IR1 was calculated by the trained coach when they failed twice to reach the front line in time. Each participant only had one attempt for this test.

Statistical analyses

All study data were analyzed with SPSS 25.0 software (SPSS Inc., Chicago, IL, USA). The Shapiro–Wilk test was used to check the normal distribution of the data, confirming that all collected data followed a normal distribution. One-way ANOVA was used to test for significant differences between age and position groups. The least significant difference (LSD) test was subsequently used as a post hoc test to compare two groups. Statistical significance was considered at $p < 0.05$. The effect sizes (ESs) were also calculated with the following criteria: 0.04-0.25, small; 0.25-0.64, moderate; and 0.64-1.0, large [22].

Results

Tables 1 and 2, and Table 3 show the anthropometric and physical characteristics among the three age groups and the playing position groups. Table 1 shows that the U16 and U17 players had significantly greater body heights ($p < 0.05$) than the U15 players did. Compared with the U15 group, the U17 and U16 groups had significantly greater muscle mass ($p < 0.05$), lower limb length ($p < 0.05$), and chest girth ($p < 0.05$) values. Moreover, with increasing age, significant differences in calf girth, thigh girth, and Achilles tendon length were found between the U17 group and the U15 group, whereas no significant differences were detected between the U17 group and the U16 group. No significant differences were found in other anthropometric characteristics among the three age groups.

Table 1 reveals that the U16 group and U17 group both had better scores than did the U15 group on the speed test and had significantly faster 5-m, 20-m, and 30-m sprinting speeds ($p < 0.05$). The results of the CMJ test, single left leg jump with arm swing, single right leg jump with arm swing, T-test, and YYIR test differed significantly ($p < 0.05$) among the age groups; the players in the U16 and U17 groups scored significantly better than those in the U15 group did. Moreover, U17 players performed significantly better on the CMJ test and YYIR test than U16 players did ($p < 0.05$).

Tables 2 and 3 show the anthropometric and physical characteristics variations among the 6 position

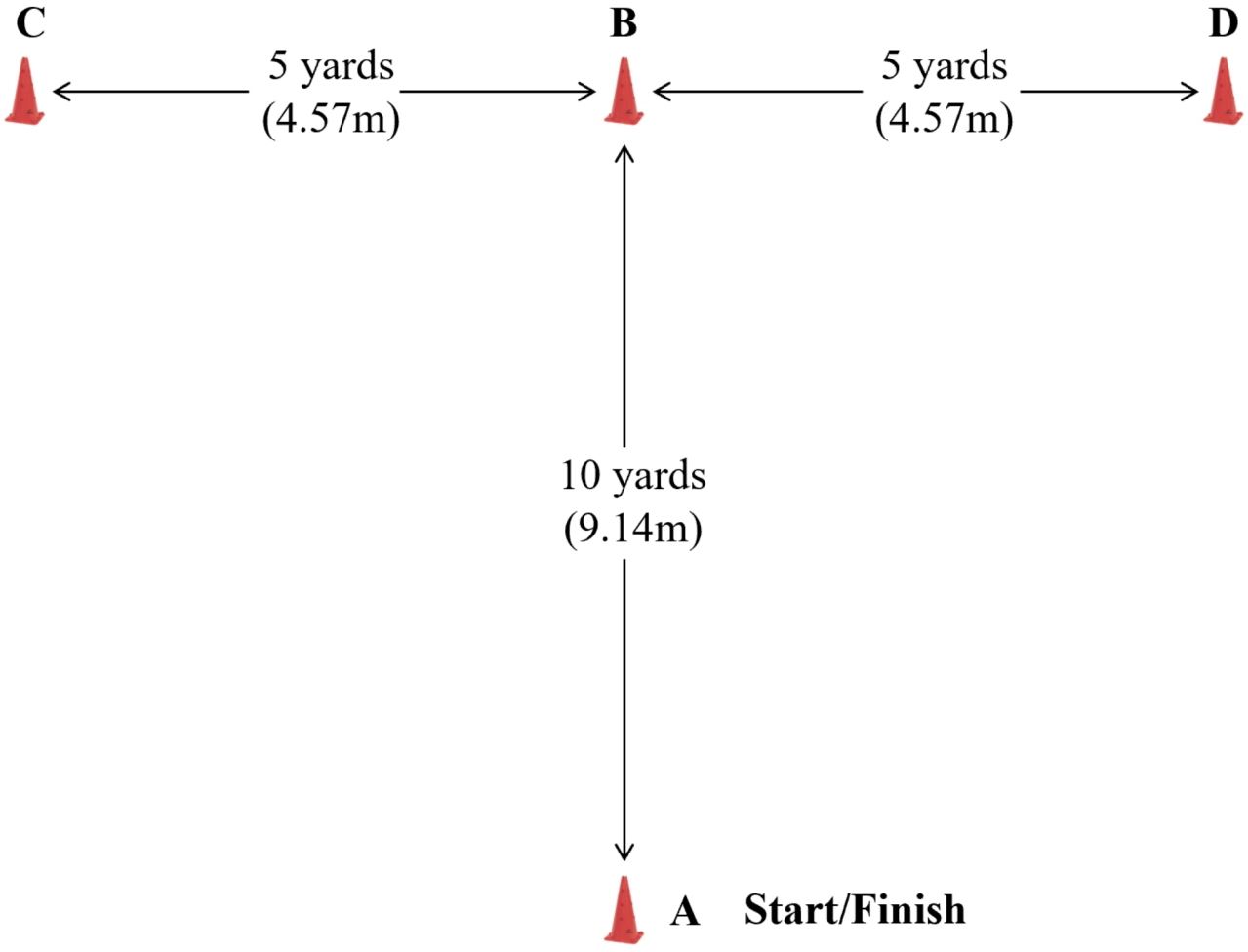

Fig. 2 Agility T-test. The athlete runs forward from cone A to cone B, then shuffles to the left (cone C), then shuffles to the right (cone D), then shuffles back to point B, before running backwards to the start/finish position (point A)

groups. Significant differences were found in body height ($p < 0.001$), body mass ($p < 0.001$), muscle mass ($p < 0.001$), chest girth ($p < 0.001$), lower limb length ($p < 0.001$), ankle circumference ($p < 0.05$), Achilles tendon length ($p < 0.001$), 20-m sprinting speed ($p < 0.05$), 30-m sprinting speed ($p < 0.05$), and the YYIR test score ($p < 0.001$) among the 6 position groups. There were no significant differences in BMI, fat mass, waist–hip ratio, thigh girth, 5-m sprinting speed, 10-m sprinting speed, jump test, or T-test values across playing positions. GKs and CDs presented significantly greater body masses ($p < 0.05$) and body heights ($p < 0.05$) than other players did. GKs differed in terms of muscle mass (greater than that of other players except defenders, $p < 0.05$), lower limb length (greater than that of other players except CDs, $p < 0.05$), Achilles tendon length (greater than that of other players except CMs, $p < 0.05$), and calf length (greater than that of other players except CMs, $p < 0.05$) and scored significantly lower on the YYIR (less than that of all other players, $p < 0.05$).

Discussion

This study investigated the anthropometric and physical characteristics and their variations among young male soccer players in various age groups (15, 16, and 17 years old) and playing positions (GKs, CDs, EDs, CMs, EMs, and FWs) among elite Chinese young male soccer players. Some findings are as follows: (1) the U16 group and the U17 group both had better scores than did the U15 group on the speed test and had significantly faster 5-m, 20-m, and 30-m sprinting speeds; (2) the CMJ test, single left leg jump test, single right leg jump test, T-test, and YYIR test scores differed significantly among the age groups; players in the U16 and U17 groups scored significantly better than did those in the U15 group, but no significant differences in the single left leg jump test, single right leg jump test, T-test, or YYIR test were found between the U16 and U17 groups; (3) there were significant differences in thigh girth between the U15 and U17 groups; (4) the GKs and CDs presented significantly greater body masses and body heights than did the

Table 1 Descriptive and comparative analysis of anthropometric and physical performance characteristics among the three age groups

Parameters	15 yr(*N* = 87)	16 yr(*N* = 99)	17 yr(*N* = 52)	F	*P*	ES η^2
Body height [cm]	173.45 ± 6.30[2,3]	176.10 ± 6.23[1]	177.08 ± 5.52[1]	7.03	**0.001**	0.442
Body mass [kg]	60.77 ± 9.11[2,3]	63.76 ± 6.97[1]	65.87 ± 6.83[1]	7.54	**<0.001**	0.689
BMI [kg/m2]	20.17 ± 2.63	21.05 ± 4.64	21.76 ± 5.88	2.28	0.105	0.377
Muscle mass [kg]	29.68 ± 3.99[2,3]	32.07 ± 3.52[1]	33.37 ± 3.38[1]	18.56	**<0.001**	0.527
Fat mass [kg]	7.62 ± 4.94	6.86 ± 3.20	7.16 ± 2.34	0.92	0.401	0.389
Waist–hip ratio [%]	0.80 ± 0.03	0.80 ± 0.04	0.80 ± 0.02	0.24	0.787	0.152
Chest girth [cm]	82.18 ± 5.55[2,3]	84.26 ± 4.40[1,3]	87.39 ± 4.37[1,2]	18.86	**<0.001**	0.687
Lower limb length [cm]	86.37 ± 5.93[2,3]	88.26 ± 4.80[1]	89.93 ± 3.92[1]	8.35	**<0.001**	0.545
Ankle circumference [cm]	21.87 ± 1.46	22.20 ± 1.43	22.06 ± 1.38	1.38	0.253	0.243
Calf length [cm]	45.20 ± 2.38[3]	46.02 ± 2.51	46.47 ± 2.30[1]	5.09	**0.007**	0.428
Thigh girth [cm]	53.68 ± 7.37[3]	54.46 ± 3.95	56.58 ± 3.83[1]	4.73	**0.010**	0.470
Achilles tendon length [cm]	26.16 ± 2.58[3]	26.56 ± 2.36	27.77 ± 3.83[1]	5.47	**0.005**	0.505
5 m speed [s]	1.67 ± 0.12[2,3]	1.602 ± 0.07[1]	1.60 ± 0.07[1]	14.46	**<0.001**	0.656
10 m speed [s]	2.61 ± 0.29	2.588 ± 0.31	2.56 ± 0.29	0.42	0.655	0.822
20 m speed [s]	3.84 ± 0.27[2,3]	3.699 ± 0.13[1]	3.70 ± 0.14[1]	14.04	**<0.001**	0.760
30 m speed [s]	5.14 ± 0.27[2,3]	4.928 ± 0.18[1]	4.90 ± 0.20[1]	27.25	**<0.001**	0.778
CMJ [cm]	41.24 ± 5.63[2,3]	43.54 ± 5.21[1,3]	45.86 ± 6.10[1,2]	11.52	**<0.001**	0.644
Single left jump [cm]	23.22 ± 4.37[2,3]	25.37 ± 4.17[1]	25.61 ± 3.89[1]	7.92	**<0.001**	0.642
Single right jump [cm]	22.98 ± 4.12[2,3]	25.51 ± 3.68[1]	26.14 ± 3.95[1]	14.07	**<0.001**	0.667
T-test [s]	11.55 ± 0.83[2,3]	10.938 ± 0.56[1]	10.74 ± 0.59[1]	29.44	**<0.001**	0.674
YYIR test	1981.20 ± 477.10[2,3]	2313.80 ± 494.40[1,3]	2246.40 ± 547.30[1,2]	23.77	**<0.001**	0.389

BMI: body mass index; CMJ: countermovement jump; YYIR: Yo-Yo intermittent recovery test; ES: effect size; [1]: $p < 0.05$ compared with 15 year; [2]: $p < 0.05$ compared with 16 year; [3]: $p < 0.05$ compared with 17 year

Table 2 Descriptive and comparative analysis of anthropometric characteristics among the different playing positions

Parameters	GK(*N* = 20)	CD(*N* = 41)	ED(*N* = 48)	CM(*N* = 44)	EM(*N* = 65)	FW(*N* = 20)	F	*P*	ESη^2
Body height [cm]	181.77 ± 3.59[3,4,5,6]	179.61 ± 5.12[3,4,5,6]	174.95 ± 4.61[1,2]	174.55 ± 6.39[1,2]	171.98 ± 5.75[1,2]	173.83 ± 6.23[1,2]	16.06	**<0.001**	0.475
Body mass [kg]	69.07 ± 7.73[4,5,6]	67.24 ± 6.77[4,5,6]	64.37 ± 6.47[5]	61.01 ± 7.82[1,2]	60.05 ± 8.49[1,2,3]	60.41 ± 5.51[1,2]	8.87	**<0.001**	0.793
BMI [kg/m2]	20.87 ± 2.08	20.84 ± 1.87	21.04 ± 2.27	20.03 ± 2.09	21.66 ± 7.68	20.00 ± 1.42	0.91	0.474	0.329
Muscle mass [kg]	43.29 ± 4.32[4,5,6]	33.63 ± 3.54[4,5]	31.86 ± 2.69	30.34 ± 4.10[1,2]	29.98 ± 3.87[1,2]	30.74 ± 3.40[1]	8.52	**<0.001**	0.603
Fat mass [kg]	7.24 ± 3.46	7.73 ± 3.29	7.94 ± 5.06	7.04 ± 3.44	6.77 ± 3.71	6.08 ± 2.07	1.05	0.388	0.433
Waist-hip ratio [%]	0.80 ± 0.04	0.79 ± 0.04	0.81 ± 0.03	0.80 ± 0.03	0.80 ± 0.03	0.79 ± 0.02	0.69	0.634	0.054
Chest girth [cm]	86.67 ± 4.41[5,6]	85.51 ± 4.30[5]	86.57 ± 5.03[4,5,6]	82.78 ± 5.55[3]	82.50 ± 5.12[1,2,3]	81.86 ± 3.67[1,3]	7.07	**<0.001**	0.585
Lower limb length [cm]	92.46 ± 3.55[3,4,5,6]	89.85 ± 7.93[5]	88.51 ± 3.29[1,5]	87.97 ± 4.50[1]	85.37 ± 3.83[1,2,3]	86.37 ± 4.42[1]	8.99	**<0.001**	0.616
Ankle circumference [cm]	22.48 ± 1.42	22.62 ± 1.57[5]	22.26 ± 1.16	22.82 ± 1.56	21.68 ± 1.25[2]	21.82 ± 0.91	3.44	**0.005**	0.237
Calf length [cm]	47.99 ± 2.15[3,4,5,6]	46.74 ± 2.66[5]	46.13 ± 1.85[1,5]	45.90 ± 2.23[1,5]	44.53 ± 2.36[1,2,3,4]	45.04 ± 2.05[1]	9.96	**<0.001**	0.489
Thigh girth [cm]	55.90 ± 4.03	55.85 ± 4.19	55.23 ± 7.17	53.89 ± 4.60	53.34 ± 4.93	55.30 ± 7.53	1.68	0.141	0.514
Achilles tendon length [cm]	29.25 ± 4.27[2,3,5,6]	27.03 ± 2.28[1]	26.58 ± 1.81[1]	27.07 ± 3.61	25.87 ± 2.33[1]	25.44 ± 2.48[1]	5.85	**<0.001**	0.500

GK: goalkeeper; CD: central defender; ED: external defender; CM: central midfielder; EM: external midfielder; FW: forward; BMI: body mass index; ES: effect size; [1]: $p < 0.05$ compared with GK [2]: $p < 0.05$ compared with CD [3]: $p < 0.05$ compared with ED [4]: $p < 0.05$ compared with CM [5]: $p < 0.05$ compared with EM [6]: $p < 0.05$ compared with FW

other players; and (5) with respect to the physical performance test, there was a significant difference only in the Yo-Yo test score between GKs and players with all other positions.

Age group comparisons of anthropometric and physical characteristics

In this study, significant differences in body mass (U15 vs. U16 vs. U17 players: 60.77 kg vs. 63.76 kg vs. 65.87 kg) and height (U15 vs. U16 vs. U17 players: 173.45 cm vs. 176.10 cm vs. 177.08 cm) were observed among 15- to 17-year-old soccer players. Similar results were reported in a previous study [14] of 14- to 18-year-old Hungarian

Table 3 Descriptive and comparative analysis of physical performance characteristics among the different playing positions

Parameters	GK(*N* = 20)	CD(*N* = 41)	ED(*N* = 48)	CM(*N* = 44)	EM(*N* = 65)	FW(*N* = 20)	F	*P*	ESη²
5 m speed [s]	1.67 ± 0.10	1.64 ± 0.10	1.61 ± 0.11	1.63 ± 0.08	1.61 ± 0.08	1.64 ± 0.13	1.72	0.130	0.709
10 m speed [s]	2.64 ± 0.32	2.55 ± 0.287	2.69 ± 0.32	2.55 ± 0.26	2.59 ± 0.32	2.49 ± 0.22	1.83	0.108	0.755
20 m speed [s]	3.84 ± 0.16	3.76 ± 0.16	3.75 ± 0.22	3.80 ± 0.27	3.70 ± 0.16	3.71 ± 0.19	2.59	**0.027**	0.742
30 m speed [s]	5.13 ± 0.23	4.99 ± 0.24	4.97 ± 0.26	5.08 ± 0.25	4.95 ± 0.22	4.96 ± 0.24	2.90	**0.015**	0.811
CMJ [cm]	44.07 ± 5.27	42.64 ± 5.78	44.73 ± 5.92	41.58 ± 6.10	43.13 ± 5.50	43.58 ± 6.01	1.55	0.175	0.730
Single left jump [cm]	25.10 ± 3.81	24.88 ± 3.79	24.88 ± 4.12	23.40 ± 4.28	24.81 ± 4.63	25.25 ± 5.16	0.93	0.461	0.729
Single right jump [cm]	25.23 ± 3.96	24.66 ± 3.51	25.25 ± 4.24	23.78 ± 4.21	24.67 ± 4.27	25.37 ± 4.51	0.78	0.567	0.636
T-test [s]	11.39 ± 0.65	11.12 ± 0.74	10.92 ± 0.81	11.14 ± 0.90	11.18 ± 0.65	11.10 ± 0.71	1.32	0.256	0.669
YYIR test	1705.30 ± 668.00[2,3,4,5,6]	2250.50 ± 557.90[1]	2465.50 ± 483.60[1]	2223.60 ± 537.50[1]	2214.80 ± 480.40[1]	2390.00 ± 438.00[1]	6.17	**<0.001**	0.390

GK: goalkeeper; CD: central defender; ED: external defender; CM: central midfielder; EM: external midfielder; FW: forward; BMI: body mass index; CMJ: countermovement jump; YYIR: Yo-Yo intermittent recovery test; ES: effect size; [1]: $p < 0.05$ compared with GK [2]: $p < 0.05$ compared with CD [3]: $p < 0.05$ compared with ED [4]: $p < 0.05$ compared with CM [5]: $p < 0.05$ compared with EM [6]: $p < 0.05$ compared with FW

male soccer players (U15 (body height: 171.83 cm; body mass: 61.52 kg), U16 (body height: 177.72 cm; body mass: 66.97 kg), and U17-18 (body height: 182.38 cm; body mass: 72.16 kg) players). Similar results were also reported in previous studies of youth soccer players' body heights and weights [8, 11, 23]. The variations in body size in the present study support the findings of previous studies that sports have beneficial effects on growth [24]. Moreover, significant differences in muscle mass were detected among 15- to 17-year-old soccer players which is in line with the previous studies [12, 25] while no significant differences in fat mass were found, in line with the previous study [12].

In this study, U17 players presented significantly greater thigh girth than U15 players did. During soccer games, thigh girth plays a vital role in ensuring excellent physical resistance when playing against opponents. Moreover, a positive correlation between thigh girth and sprinting ability has been revealed [26, 27]. Significant differences in thigh girth were found between U17 players and U15 players ($p < 0.05$), whereas no such significant differences were found between U17 players and U16 players or between U16 players and U15 players. We suspected that physical maturation from 15 to 17 years of age, along with chronic sport-related training during this time, was the reason for the difference in thigh girth between U15 and U17 players.

The results of this study revealed significant differences in physical test results among the age groups ($p < 0.001$), except the results of the 10-m sprinting test ($p = 0.655$). Moreover, the results of the soccer players aged 15 to 17 years on all the speed, lower limb jump, and agility tests also revealed a consistent trend toward better performance scores with increasing age, which is in line with the findings of previous studies [10, 28–30].

Agility is vital to perform rapid whole-body movements with a change in velocity or direction in response to a stimulus [31]. Lower limb strength, speed, and agility are specific abilities of soccer players, and there is a positive relationship among these three abilities [32–34]. For this reason, speed, agility, and lower limb strength showed similar trends in this study. *Another possible explanation for the increase with age from 15 to 17 years is the growth and maturation during late puberty.* [35] *In addition, the muscle mass of young male athletes increased more rapidly after the age of 16 years.* [36] *For the above reasons, the results for agility, lower limb power, and speed tests revealed that older players tended to perform better in the present study.*

The Yo-Yo IR1 test is frequently used to measure aerobic capacity; during this test, athletes must reply on aerobic energy supply systems to exercise with high intensity and recover in the period between repeated performances [21, 37]. A previous study reported that the distances in the Yo-Yo IR1 test differed with increasing age in U15, U17, and U19 high-level youth soccer players [38], which is similar to the findings of this study. An increase in the aerobic capacity of male adolescents was significantly related to their physical development (age, height, and weight) [39]. Moreover, the VO_2 peak of male youth athletes increased rapidly until the age of 18, which caused a difference in the aerobic capacity of young athletes among age groups through the combination of growth, development and training [40]. These findings support our results that older players performed better on the Yo-Yo IR1 test.

Comparisons of anthropometric and physical characteristics among playing position groups

With respect to anthropometric characteristics (e.g., body mass and body height), a previous study reported that the GK group presented a significantly greater body height than the other groups did, contributing to GKs having a high reach and covering a large part of the goal, which is necessary to efficiently prevent opponents from scoring [41]. Similar to GKs, CDs have been reported to present greater body height and body mass than players in other positions [8]. Similar to the previous study, in this study, GKs and CDs presented significantly greater body heights than players in other positions did and presented significantly greater body masses than CMs, EMs, and FWs did. Players who have a greater body height and mass are more suitable for meeting the requirements of the GK and CD positions [8]. However, a previous study on the anthropometric characteristics of Belgian soccer players in top-level playing positions reported that FWs had greater body heights and masses than did midfielders and EDs [41]. Therefore, we inferred that the differences in anthropometric values among soccer players with different playing positions are caused mainly by the identification criteria of the coaches. Additionally, in this study, there were significant differences ($p < 0.001$) in body height, body mass, muscle mass, chest girth, lower limb length, calf length, and Achilles tendon length among the six playing position groups (GKs, CDs, EDs, CMs, EMs, FWs). Different needs across the six playing positions lead to different anthropometric characteristics [42].

Generally, the running characteristics of GKs in soccer matches are different from those of players with other playing positions [43]. GKs run shorter distances during soccer matches and have significantly lower maximal oxygen consumption (VO_2max) [42]. Consistent with the results obtained in previous studies, GKs scored lower on the Yo-Yo IR1 test in the present study. In addition, previous studies reported that the mean VO_2 max values of elite Belgian soccer players were as follows: EDs > midfielders > FWs > CDs [42], which is similar to the results of this study, in which EDs performed best on the Yo-Yo IR1 test.

Limitations and future directions

The main limitation of this study is that the data did not involve motion analysis, which provides valuable information on adolescent soccer players' physical characteristics in soccer matches, and only an in-depth analysis of the anthropometric and physical characteristics of adolescent male soccer players was conducted. The second limitation was that all tests were performed in the midseason period, but players' performance may vary between the preseason and midseason. What's more, the biological maturation which may affect the variables of the study was not measured. Thus, in future research, it is necessary to explore whether there is a significant difference in anthropometric and performance characteristics between the preseason and midseason. Moreover, it is also necessary to perform motion analysis to study the characteristics of soccer players with various playing positions, ages, biological maturation, and competitive levels. The outcomes provide coaches with data for training and selecting youth soccer players, helping them optimize individual training programs according to the characteristics and demands of various age groups and playing positions.

Conclusion

Comparisons of anthropometric characteristics revealed significant differences in body height, body mass, muscle mass, chest girth, lower limb length, ankle circumference, calf length, and Achilles tendon length among players in various playing positions. In the comparisons of physical performance, the GKs scored significantly lower on the YYIR than the other players did. The CMJ test, single left leg jump test, single right leg jump test, T-test, and YYIR test scores differed significantly among the age groups. The U16 group and U17 group both had better scores than did the U15 group on the speed test.

The findings of this study provide anthropometric and physical profiles of Chinese male youth soccer players, helping coaches better understand the anthropometric and physical characteristics of various age groups and playing positions in selecting and recruiting youth soccer players. It may be useful for coaches to optimize individual trainings according to the anthropometric and physical characteristics of various age groups and playing positions.

Author contributions
Z.S., X.Z, and S.S designed the study. Z.S. and X.L. contributed to data acquisition. Z.S., H.F., and X.L. conducted data analysis and interpretation. Z.S. and X.Z. drafted the manuscript. S.S. and H.F. checked and revised the manuscript. All authors approved the manuscript.

Funding
This study was supported by Teaching and Research Projects in Higher Education Institutions of Hubei Province (No.2022067) and Huazhong University of Science and Technology Double First-Class Funds for Humanities and Social Sciences (Grant No. 2023WKYXQWN005).

Data availability
The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study design, protocol, and risk were well known to the players and their legal guardians. This study was reviewed and approved by the Institutional Ethics Board of Tongji Medical College, Huazhong University of Science and Technology, China (Notification Number [2023] IEC (S172)). This study followed the ethical principles of the Helsinki Declaration for human research. Written informed consent forms were obtained from all the participants and guardians of the minors.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 26 October 2024 / Accepted: 30 January 2025
Published online: 10 February 2025

References

1. Liu SH. Analysis on some biochemical indexes, physical fitness and physique of our male Elite Junior Soccer players. Sports Sci. 2004;24:15–8.
2. Morris T. Psychological characteristics and talent identification in Soccer. J Sports Sci. 2000;18:715–26. https://doi.org/10.1080/026404100501200 96.
3. Lesinski M, et al. Effects of Soccer Training on Anthropometry, body composition, and physical fitness during a Soccer season in female Elite Young athletes: a prospective cohort study. Front Physiol. 2017;8:1093. https://doi.org/10.3389/fphys.2017.01093.
4. Leão C, et al. Anthropometric Profile of Soccer Players as a determinant of position specificity and methodological issues of body composition estimation. Int J Environ Res Public Health. 2019;16:2386. https://doi.org/10.3390/ijerph16132386.
5. Reeves MJ, Roberts SJ. A Bioecological Perspective on Talent Identification in Junior-elite Soccer: a pan-european perspective. J Sports Sci. 2020;38:1259–68. https://doi.org/10.1080/02640414.2019.1702282.
6. Gonaus C, Müller E. Using physiological data to Predict Future Career Progression in 14-to17-year-old Austrian Soccer Academy players. J Sports Sci. 2012;30:1673–82. https://doi.org/10.1080/02640414.2012.713980.
7. Bidaurrazaga-Letona I, et al. Longitudinal Field Test Assessment in a Basque Soccer Youth Academy: a Multilevel modeling Framework to Partition effects of Maturation. Int J Sports Med. 2014;36:234–40. https://doi.org/10.1055/s-0034-1385881.
8. Lago-Peñas C, et al. Anthropometric and physiological characteristics of Young Soccer players according to their playing positions: relevance for competition success. J Strength Cond Res. 2011;25:3358–67. https://doi.org/10.1519/JSC.0b013e318216305d.
9. Vanderford ML, et al. Physiological and Sport-specific Skill response of Olympic Youth Soccer athletes. J Strength Cond Res. 2004;18:334–42. https://doi.org/10.1519/R-11922.1.
10. Silva AF, et al. Variations of the locomotor Profile, sprinting, change-of-Direction, and jumping performances in Youth Soccer players: interactions between playing positions and age-groups. Int J Environ Res Public Health. 2022;19:998. https://doi.org/10.3390/ijerph19020998.
11. Nikolaidis PT. Vassilios Karydis, N. Physique and body composition in soccer players across adolescence. Asian J Sports Med. 2011;2:75–82. https://doi.org/10.5812/asjsm.34782.
12. Spehnjak M, Gušić M, Molnar S, Baić M, Andrašić S, Selimi M, Mačak D, Madić DM, Žilič Fišer S, Sporiš G, Trajković N. Body composition in Elite Soccer players from Youth to Senior Squad. Int J Environ Res Public Health. 2021;18(9):4982. https://doi.org/10.3390/ijerph18094982.
13. Towlson C, et al. Relative age, maturation and physical biases on position allocation in Elite-Youth Soccer. Int J Sports Med. 2017;38:201–9. https://doi.org/10.1055/s-0042-119029.
14. Soós I, et al. Anthropometric and physiological profiles of Hungarian Youth Male Soccer players of varying ages and playing positions: a Multidimensional Assessment with a critical Approach. Int J Environ Res Public Health. 2022;19:11041. https://doi.org/10.3390/ijerph191711041.
15. Murr D, Raabe J, Höner O. The prognostic value of physiological and physical characteristics in Youth Soccer: a systematic review. Eur J Sport Sci. 2018;18(1):62–74. https://doi.org/10.1080/17461391.2017.1386719.
16. McLester CN, Nickerson BS, Kliszczewicz BM, McLester JR. Reliability and agreement of various InBody body composition analyzers as compared to dual-energy X-Ray absorptiometry in healthy men and women. J Clin Densitom 23. 2018).;443–50. https://doi.org/10.1016/j.jocd.2018.10.008..
17. Toselli S, et al. Assessment of body composition and physical performance of Young Soccer players: differences according to the competitive level. Biology. 2022;11:823. https://doi.org/10.3390/biology11060823.
18. Mitchell CJ, Sale DG. Enhancement of Jump Performance after a 5-RM Squat is Associated with Postactivation Potentiation. Eur J Appl Physiol. 2011;111:1957–63. https://doi.org/10.1007/s00421-010-1823-x.
19. Vandendriessche JB, et al. Biological maturation, morphology, Fitness, and Motor Coordination as Part of a selection strategy in the search for International Youth Soccer players (Age 15–16 years). J Sports Sci. 2012;30:1695–703. https://doi.org/10.1080/02640414.2011.652654.
20. Sassi RH, et al. Relative and absolute reliability of a modified agility T-test and its relationship with vertical jump and straight sprint. J Strength Cond Res. 2009;23:1644–51. https://doi.org/10.1519/JSC.0b013e3181b425d2.
21. Krustrup P, et al. The yo-yo intermittent recovery test: physiological response, reliability, and validity. Med Sci Sports Exerc. 2003;35:697–705. https://doi.org/10.1249/01.MSS.0000058441.94520.32.
22. Ferguson CJ. An effect size primer: a Guide for clinicians and Researchers. Prof Psychol Res Pr. 2009;40:532–8.
23. Malina RM, Figueiredo AJ, Coelho-E-Silva MJ. Body size of Male Youth Soccer players 1978–2015. Sports Med (Auckland N Z). 2017;47:1983–92. https://doi.org/10.1007/s40279-017-0743-x.
24. Cacciari E, et al. Effects of Sport (football) on growth: Auxological, Anthropometric and Hormonal aspects. Eur J Appl Physiol Occup Physiol. 1990;61:149–58. https://doi.org/10.1007/BF00236710.
25. Mala L, Maly T, Cabell L, Hank M, Bujnovsky D, Zahalka F, Anthropometric. Body composition, and morphological Lower Limb asymmetries in Elite Soccer players: a prospective cohort study. Int J Environ Res Public Health. 2020;17(4):1140. https://doi.org/10.3390/ijerph17041140.
26. Sporis G, et al. Impact of body composition on performance in Fitness tests among personnel of the Croatian Navy. Coll Antropol. 2011;35:335–9.
27. Barbieri D, et al. Body composition and size in Sprint athletes. J Sports Med Phys Fit. 2017;57:1142–6. https://doi.org/10.23736/S0022-4707.17.06925-0.
28. Mendez-Villanueva A, et al. Age-related differences in acceleration, Maximum running speed, and repeated-sprint performance in Young Soccer players. J Sports Sci. 2011;29:477–84. https://doi.org/10.1080/02640414.2010.536248.
29. Al Haddad H, et al. Peak Match Speed and maximal sprinting speed in Young Soccer players: Effect of Age and playing position. Int J Sports Physiol Perform. 2015;10:888–96. https://doi.org/10.1123/ijspp.2014-0539.
30. Slimani M, Nikolaidis PT. Anthropometric and physiological characteristics of male Soccer players according to their competitive level, playing position and Age Group: a systematic review. J Sports Med Phys Fit. 2019;59:141–63. https://doi.org/10.23736/S0022-4707.17.07950-6.
31. Benvenuti C, et al. Agility Assessment in Female Futsal and Soccer players. Med (Kaunas Lithuania). 2010;46:415–20.
32. Chaouachi A, et al. Determinants analysis of change-of-direction ability in Elite Soccer players. J Strength Cond Res. 2012;26:2667–76. https://doi.org/10.1519/JSC.0b013e318242f97a.

33. Jones S, et al. Field based lower limb strength tests provide insight into Sprint and Change of Direction ability in Academy footballers. Scand J Med Sci Sports. 2021;31:2178–86. https://doi.org/10.1111/sms.14039.
34. Kabacinski J, et al. Relationship between isokinetic knee strength and speed, agility, and Explosive Power in Elite Soccer players. Int J Environ Res Public Health. 2022;19:671. https://doi.org/10.3390/ijerph19020671.
35. Falk B. Bar-Or, O. Longitudinal changes in Peak Aerobic and Anaerobic Mechanical Power of Circumpubertal Boys. Pediatr Exerc Sci. 1993;5:318–31.
36. Cossio Bolaños MA, et al. Muscle Mass in Children and adolescents: proposed equations and reference values for Assessment. Front Endocrinol. 2019;10:583. https://doi.org/10.3389/fendo.2019.00583.
37. Bangsbo J, Iaia FM, Krustrup P. The Yo-Yo Intermittent Recovery Test: a useful tool for evaluation of physical performance in intermittent sports. Sports Med (Auckland N Z). 2008;38:37–51. https://doi.org/10.2165/00007256-200838010-00004.
38. Deprez D, et al. The Yo-Yo Intermittent Recovery Test Level 1 is Reliable in Young High-level Soccer players. Biol Sport. 2015;32:65–70. https://doi.org/10.5604/20831862.1127284.
39. Baxter-Jones A, Goldstein H, Helms P. The development of Aerobic Power in Young athletes. J Appl Physiol (Bethesda Md:985). 1993;75:1160–7. https://doi.org/10.1152/jappl.1993.75.3.1160.
40. Zhao K, et al. A 2-year Longitudinal follow-up of performance characteristics in Chinese Male Elite Youth athletes from Swimming and Racket sports. PLoS ONE. 2020;15:e0239155. https://doi.org/10.1371/journal.pone.0239155.
41. Boone J, et al. Physical fitness of Elite Belgian Soccer players by player position. J Strength Cond Res. 2012;26:2051–7. https://doi.org/10.1519/JSC.0b013e318239f84f.
42. Bangsbo J, Nørregaard L, Thorsø F. Activity Profile of Competition Soccer. Can J Sport Sci = Journal canadien des Sci du Sport. 1991;16:110–6.
43. Palucci Vieira LH, et al. Match running performance in Young Soccer players: a systematic review. Sports Med (Auckland N Z). 2019;49:289–318. https://doi.org/10.1007/s40279-018-01048-8.

Publisher's note