Sport Sci Health (2015) 11:321–328
DOI 10.1007/s11332-015-0243-z

ORIGINAL ARTICLE

Anthropometry and fitness of young elite soccer players by field position

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Received: 24 July 2015 / Accepted: 22 September 2015 / Published online: 9 October 2015

Abstract
Purpose The present study aimed at determining anthropometric and physical fitness characteristics of boys, who were previously selected to participate in specialized soccer training, according to their positions in the game field.
Methods Two hundred and ninety-six boys ageing from 10 to 13 years old were evaluated, after being recruited and assigned to the position each one would play, as determined by the coaches: goalkeepers ($n = 26$), defenders ($n = 77$), midfielders ($n = 113$) and forwards ($n = 80$). All of them had been through selection phase in a soccer club and started specialized training 3 times/week, 3 h/day, 2 months before the assessment.
Results Goalkeepers and defenders are taller, heavier and have more lean mass than players from other positions ($p < .01$). They also have more flexibility, lower limb strength and muscle power than midfielders and forwards ($p < .05$). Forwards, in turn, present less adiposity than midfielders, defenders and goalkeepers (12.1 ± 4.5 vs. 14.0 ± 5.7; 15.3 ± 5.1 and 17.0 ± 6.7, respectively, $p < .01$). Agility, elbow flexion strength and maximal oxygen consumption did not differ significantly among players of different field positions.
Conclusion Data show clear differences among athletes from each field position. Goalkeepers and defenders are the tallest and heaviest of all players, and they also have more lean mass than midfielders and forwards. Flexibility, lower limb strength and muscle power are highlighted features in goalkeepers when compared to players from other field positions. Conversely, forwards present lower adiposity than athletes from all other positions.

Keywords Soccer · Growth · Development · Boys

Introduction

Soccer is the world's most popular sport [1], and has attracted a lot of scientific interest related to anthropometric and physical fitness aspects of elite players [1–12]. However, little is known about players' characteristics according to their field position [1, 2, 8, 9]. When it comes to young athletes, less than 14 years of age, although there is some information available [1, 6, 9, 11, 13], only a small number deals with issues related to field positions [1, 6, 9]. To some extent, the lack of information in this age group is rather surprising, since the world's biggest clubs have youth teams and generate considerable revenue out of them. It is very important to acknowledge the anthropometric and physical fitness characteristics of each field position, as the progresses in physical training aim to contribute to the distinct tactical and competitive demands of this sport [3–5]. Additionally, financial investment and

Electronic supplementary material The online version of this article (doi:10.1007/s11332-015-0243-z) contains supplementary material, which is available to authorized users.

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the specificity of training and matches, based on specific demands of each field position [3–5], require such information to optimize activities in soccer [3, 5, 10].

Physiological demands of soccer require predominantly the aerobic metabolic pathway, followed by lactic and alactic anaerobic pathways. Muscle strength is mostly dynamic and explosive, and agility and speed are the most requested capacities in coordinated manoeuvres of dribbling, passing and ball control [1]. Among others, maximal oxygen intake (VO_{2max}) is considered one of the most common predictors of aerobic fitness and, therefore, its assessment is especially important [1]. In professional adult soccer players, VO_{2max} varies between 50 and 75 ml/kg/min (155–205 ml/kg$^{0.75}$/min) [1, 10]. When comparing by field position, Stolen et al. [1] did not notice any differences among goalkeepers, defenders, midfielders and forwards, differently from Reilly et al. [8] who observed diverse values of VO_{2max}: goalkeepers $<$ defenders $<$ forwards $<$ midfielders and fullbacks. When it comes to young athletes under 16 years of age (under-14, under-15 and under-16), data indicate VO_{2max} values varying from 52.9 and 59.0 ml/kg/min (140.6–165.2 ml/kg$^{0.75}$/min) [1, 11], clearly within the adults range. Stroyer et al. [9] indicate that VO_{2max} of midfielders and forwards boys (12–14 years old) is superior to the one of the defenders, regardless of maturational stage, probably due to the longer distance covered by players of this position [1, 3, 4, 14]. Conversely, other studies did not verify differences among field positions of 13–16-year-old adolescents [6, 8]. Available data do not allow us to draw safe conclusions regarding VO_{2max}, nor even about the impact of this parameter on the sports future of children, adolescents and adults in different field positions.

Strength and muscle power are as important components to soccer as it is aerobic resistance [1]. Although evidences on muscle strength are scarce and widely based on isokinetic tests [1] or on indirect measures of strength [1], some authors ponder that differences observed in muscle strength concerning field position are probably related to players' selection for each position [8]. Le Gall et al. [15] and Sporis et al. [16] could not find consistent differences in muscle strength of children and adolescents of international professional level in relation to the amateurs, as well as no difference among the field positions [15]. However, others verified differences among the positions [1], specially revealing lower values amongst midfielders [1, 2, 8]. Existing data on lower limb muscle power, assessed by vertical jump, indicate variation between 29.2 and 32.6 cm for children (12–13 years old), around 32 cm for non-elite players, 53.0 cm for young athletes and 39.0–61.0 cm in adults [1]. When divided by field position, no significant differences were observed in comparisons among field positions in adults, and muscle power values were between 38 and 61 cm [1]. There are no data available on children.

Speed and agility are other vital components to soccer performance [1, 10]. Studies with adults that employed speed protocols with 5–40 m sprints already demonstrated a speed variation of 5.26–7.48 m/s [1] and, as expected, speed of children and adolescents [1] was below the one verified in adults [1]. A few studies evaluated speed comparing field positions, and did not find significant differences among goalkeepers, defenders, midfielders and forwards [6, 8, 16]. Available data on agility also do not reveal significant differences among field positions in adults [7], and there are no available studies with children and adolescents. The need for information regarding this variable is justifiable by the strong correlation verified by Wisloff et al. [12] among agility, assessed in the 10 m test, maximal muscle strength (1RM) and lower limb muscle power (vertical jump), equally important physical capacities for soccer performance.

Considering the lack of information about children and adolescents by field position, the aim of this study was to assess anthropometric and physical fitness aspects of elite soccer players, ageing from 10 to 13 years old. This study's hypothesis was that there are anthropometric and physical fitness differences among field positions. Additionally, we aimed to create normative tables to provide conditions for researchers, coaches, scouts and physical trainers to evaluate and select players with high potential to succeed in elite soccer.

Methods

Participants

Boys ageing from 10 to 13 years old, from several parts of Brazil, mostly participants of soccer schools, applied for a selection process conducted by coaches of one of the most important soccer clubs in Brazil (three times South-American and world champion). This selection process was aimed at assessing physical constitution and abilities to play soccer (dribbling, kicking, passing, heading and positioning), to choose players for different field positions. Subsequent to this process, boys engaged in a training program developed by the soccer club (3 times/week, 3 h/day). Evaluations occurred 2 months after the beginning of this training regimen, when players had already been assigned to their field positions. The final sample, subjected to all measurements and tests, consisted of 296 male soccer athletes: 26 goalkeepers, 77 defenders, 113 midfielders, and 80 forwards in the beginning of the seasons of 2006 and 2007.

All procedures performed in this study were approved by local ethics committee (protocol number 14/2006) and were in accordance with national ethical standards and with 1964 Helsinki declaration and its later amendments. Informed written consent was obtained from all parents/guardians of participants included in the study.

Anthropometry

Height was measured in an appropriate stadiometer, with precision of 0.1 cm [17]. Body weight was obtained using a digital scale (Filizola, Sao Paulo, Brazil), with precision of 0.1 kg, with participants wearing shorts only [17]. Body composition and somatotype characteristics were estimated through the anthropometric method. Skinfolds were obtained using a Lange skinfold caliper, with gradations of 1.0 mm. Skinfold thickness were taken from the following sites: lateral forearm, medial forearm, biceps, triceps, subscapular, iliac crest, supraspinal, abdominal, front thigh, medial calf and popliteal [17]. Each skinfold was measured three times and the median value was used for calculations. The girths of relaxed forearm, flexed and tensed arm, thigh and calf were taken using a flexible tape, with gradations of 0.1 cm. Bone breadths of the humerus (biepicondylar), wrist (bi-styloid), femur (biepicondylar) and bi-malleolus [17] were determined using a 30 cm anthropometer, with gradations of 0.1 cm (Lafayette Instrument Company, IN, USA).

Absolute adiposity was assessed through the sum of two skinfolds (tricipital and subscapular), and through the sum of all 11 skinfolds assessed. Body composition was determined through the following variables: percent body fat (%Fat), lean body mass (LBM), muscularity (upper arm muscle area—UAMA) [18], and somatotype of Heath and Carter [17]. The %Fat was estimated using the equations of Slaughter [17], through the sum of the triceps (TR) and subscapular (SS) skinfolds, as follows: boys with a sum inferior to 35 mm: $\%\text{Fat} = 1.21 \times (\text{TR} + \text{SS}) - 0.008 \times (\text{TR} + \text{SS})^2 - 3.4$; boys with a sum equal or greater than 35 mm: $\%\text{Fat} = 0.783 \times (\text{TR} + \text{SS}) + 1.6$. Participants were divided into four groups according to fat percentage: underweight (inferior to 10 %); adequate adiposity (between 10 and 20 %); excess body fat (between 20 and 25 %); obese (superior to 25 %) [19]. Body fat weight was calculated as follows: fat weight = %Fat × weight/100. Lean body mass was determined by subtracting body fat weight from total body weight. Muscularity (cm^2) [18] was estimated using the following equation: $[\text{arm circumference} - (\pi \times \text{TR})]^2/4\pi$. Somatotype of Heath and Carter was calculated as described in Eston and Reilly [17]. Additionally, body mass index (BMI, kg/m^2) was calculated using the equation BMI = weight (kg)/height (cm)/height (cm) × 10,000.

Physical fitness

Physical fitness was determined through the following tests: (1) isometric strength: handgrip, knee extension and elbow flexion [20], (2) agility: shuttle-run [21], (3) back and hamstrings flexibility: sit-and-reach test of Wells and Dillon [21], (4) power of lower limbs: vertical jump [20], (5) 1000 m run/walk test to estimate the maximum oxygen consumption (VO_{2max}) [22], and (6) maximal number of abdominal crunches in 60 s [20].

For upper body characteristics assessment, isometric grip strength test was performed using a JAMAR isometric hand dynamometer, with a precision of 0.1 kg (Bolingbrook, IL). Values of isometric strength of knee extension (starting at 120° of knee flexion) and elbow flexion (with elbows in a 90° angle) were obtained using a Takey dynamometer (Takey Physical Fitness Test, Japan), with precision of 0.1 kg. After familiarization, three maximal attempts were performed, with 60 s of rest between each, and the best result was used for analysis.

Agility (shuttle-run) was determined by measuring the fastest time it took for the participant to alternately take two small wooden objects (5 cm × 5 cm × 10 cm), covering a distance of 9.15 m. Participants made three attempts and the best result obtained was used for analysis [21].

Back and hamstrings flexibility was determined through sit-and-reach test. The maximal distance reached (cm), with one hand parallel to the other and extended knees, was used as an indicative of back and hamstrings flexibility. Participants made three attempts and the best result was used for analysis [21].

Lower limbs power was measured through the vertical jump test with assistance of the upper limbs and body movement (jumping with both inferior limbs after three steps). The difference between the highest point reached during jumping and total height was used as an indicative of lower limbs power. Participants made three attempts and the best result was used for analysis.

The sit-ups test in 60 s aimed at evaluating local muscle endurance. Lying, with knees flexed in 90°, feet slightly apart, forearms crossed on chest and hands leaning on shoulders, boys performed the highest possible number of trunk flexions and extensions in 60 s. During flexion, forearms touched thighs, and in trunk extension the back touched the floor. Participants made one attempt and the result obtained was used for analysis.

Cardiorespiratory fitness was determined by calculating VO_{2max} after the 1000 m run/walk test [22]. The time spent (s) to finish the test was used to calculate VO_{2max} (ml/kg/min), as follows: $VO_2 = (652.17 - \text{time})/6.762$.

Statistical analysis

Results were expressed as means ± standard deviations. Boys were put into groups according to their field position. Parametric data were compared using one-way ANOVA, followed by Tukey's post hoc test. Results were considered statistically different when $p < .05$. Cohen's effect size (ES) was calculated and differences were considered significant when ES > 0.5. We also calculated Pearson's correlation coefficient (r) to determine the existence or not of associations between the variables agility and strength and muscle power. A statistical package, GraphPad Prism 6.0 for Windows (http://www.graphpad.com), was used for the analysis.

Results

Anthropometric and body composition data (means ± standard deviations) are described in Table 1. Regarding age, there was only a significant difference in comparisons between goalkeepers and midfielders (12.4 ± 0.8 vs. 11.9 ± 0.8, $p < .05$). Anthropometric data indicate that goalkeepers and defenders were significantly taller (164.2 ± 7.9 and 156.0 ± 9.9 vs. 149.6 ± 8.4 and 147.0 ± 10.9, $p < .01$), heavier (52.5 ± 8.9 and 45.1 ± 9.7 vs. 39.8 ± 7.3 and 37.9 ± 8.9, $p < .01$) and exhibited more lean mass (43.3 ± 6.7 and 38.0 ± 7.8 vs. 34.1 ± 5.8 and 33.3 ± 7.4, $p < .01$) than midfielders and forwards, respectively. Forwards exhibited lower values of adiposity (%Fat) than all the other athletes (12.1 ± 4.5 vs. goalkeepers: 17.0 ± 6.7; defenders: 15.3 ± 5.1; midfielders: 14.0 ± 5.7, $p < .01$). Additionally, UAMA was significantly higher in goalkeepers when compared to defenders, midfielders and forwards (36.0 ± 6.2 vs. 28.9 ± 6.8; 27.2 ± 5.3 and 26.9 ± 6.3, respectively, $p < .001$). Results regarding somatotype indicate predominance of mesomorphy, followed by ectomorphy and endomorphy. No significant differences were identified among field positions concerning mesomorphy and ectomorphy, but goalkeepers exhibited significantly more endomorphy than midfielders and forwards ($p < .05$) as well as defenders when compared to forwards ($p < .05$).

Physical fitness results (means ± standard deviations) are described in Table 2.

Handgrip strength of goalkeepers and defenders was significantly higher than the one of midfielders and forwards (57.1 ± 12.8 and 51.9 ± 13.8; vs. 46.0 ± 11.0 and 43.9 ± 12.9, respectively, $p < .05$). Regarding lower limb strength, goalkeepers exhibited significantly higher results than soccer players from all other field positions (43.6 ± 5.2 vs. defenders: 40.8 ± 7.1; midfielders: 40.0 ± 7.5; forwards: 38.6 ± 6.7, $p < .05$). Lumbar and ischiotibial flexibility (sit and reach) was significantly higher ($p < .05$) among goalkeepers when compared to all other players. Muscle power (vertical jump) of goalkeepers was significantly higher than the one of forwards only ($p < .05$). Results of elbow flexion strength, local muscle resistance, agility and VO_{2max} did not differ significantly among players of different field positions. However, when VO_{2max} was expressed in terms of lean mass (allometric scale), we verified that results of goalkeepers and defenders were significantly higher than the one of forwards ($p < .01$). We additionally established Pearson's correlation coefficient (r) between the results of the shuttle run test (agility) and strength and muscle power tests (vertical jump). Associations were negative, indicating inverse relationship between agility, strength and muscle power tests. Differently from data obtained with adults, correlations between agility and handgrip (left and right), lower limbs strength, and elbow flexion were lower than −0.25, indicating a weak relation. However, association between agility and lower limb power ($r = -.53$, $p < .0001$) was moderate.

From the data obtained in this sample of 296 boys, suggestive normative tables were built, in percentiles (Tables 3–7—supplementary material).

Discussion

Our main findings indicate that goalkeepers and defenders are taller, heavier, and have more lean mass than midfielders and forwards. Goalkeepers also have more flexibility, lower limb strength and muscle power than other players. On the other hand, forwards exhibit lower adiposity than athletes from other positions. The relative scarcity of anthropometric and physical fitness information of high-level athletes under 14 years of age [9] highlight the importance of data from large samples, as the one in the present study. Boys from this study represent the elite of world soccer in this age group, as the club chosen for this analysis is among the first ten clubs ranked by FIFA, and has won three world titles among professionals and two world titles in under-15 categories.

With regard to anthropometry, our data showed that goalkeepers stand out for being taller, heavier and exhibiting higher adiposity when compared to other players of this age group, which is in agreement with what was reported by previous studies [23, 24]. Goalkeepers' lean mass also seems to be higher than the one of all other athletes, although other authors have only verified differences between defenders and midfielders [24]. It is not a surprise that goalkeepers and defenders display a higher physical structure, since these positions demand a high degree of physical contact and marking, and this probably induces the choice of players with these characteristics in trials.

Table 1 Anthropometric and body composition characteristics of soccer players by field position

	Goalkeepers	Defenders	Midfielders	Forwards
n	26	77	113	80
Age (years)	12.4 ± 0.8^{aA}	12.2 ± 0.8^{abAB}	11.9 ± 0.8^{bB}	12.1 ± 0.9^{abAB}
Height (cm)	164.2 ± 7.9^{aA}	156.0 ± 9.9^{bB}	149.6 ± 8.4^{cC}	147.0 ± 10.9^{cC}
Weight (kg)	52.5 ± 8.9^{aA}	45.1 ± 9.7^{bB}	39.8 ± 7.3^{cC}	37.9 ± 8.9^{cC}
BMI (kg/m^2)	19.3 ± 1.9^{aA}	18.3 ± 2.2^{abAB}	17.6 ± 1.8^{bcBC}	17.3 ± 1.8^{cC}
Skinfolds (mm)				
Lateral forearm	7.2 ± 3.2^{aA}	6.9 ± 2.4^{aA}	6.8 ± 2.8^{aA}	5.7 ± 2.1^{bB}
Medial forearm	6.2 ± 2.6^{aA}	5.4 ± 2.1^{aA}	5.3 ± 2.6^{abAB}	4.4 ± 1.7^{bB}
Biceps	5.8 ± 2.9^{aA}	5.0 ± 2.2^{aA}	5.2 ± 2.8^{aA}	4.3 ± 1.9^{aA}
Triceps	12.0 ± 5.7^{aA}	10.6 ± 4.2^{aA}	9.9 ± 4.5^{abAB}	8.7 ± 3.6^{bB}
Subscapular	7.9 ± 2.7^{aA}	7.1 ± 2.1^{abAB}	6.6 ± 2.6^{bB}	5.6 ± 1.6^{cC}
Iliac crest	15.8 ± 7.4^{aA}	11.4 ± 5.2^{bB}	10.1 ± 6.2^{bcBC}	9.2 ± 5.0^{cC}
Supraspinale	7.8 ± 4.0^{aA}	6.2 ± 2.7^{abAB}	5.6 ± 2.9^{bB}	5.0 ± 2.5^{cC}
Abdominal	11.5 ± 5.7^{aA}	9.0 ± 4.0^{abAB}	8.5 ± 4.9^{bB}	7.5 ± 4.6^{cC}
Front thigh	18.0 ± 6.9^{aA}	15.9 ± 6.7^{abAB}	14.6 ± 6.4^{abAB}	13.3 ± 5.0^{bB}
Medial calf	12.1 ± 5.1^{aA}	10.5 ± 3.9^{aA}	9.7 ± 4.3^{abAB}	8.4 ± 3.7^{bB}
Popliteal	10.4 ± 4.7^{aA}	8.5 ± 3.3^{aA}	8.1 ± 4.0^{abAB}	7.0 ± 3.4^{bB}
Bone breadths (cm)				
Humerus	6.7 ± 0.4^{aA}	6.3 ± 0.5^{bB}	6.1 ± 0.5^{cC}	6.0 ± 0.5^{cC}
Wrist (bi-styloid)	5.2 ± 0.4^{aA}	5.0 ± 0.4^{aA}	4.8 ± 0.4^{bB}	4.8 ± 0.4^{bB}
Femur	9.7 ± 0.5^{aA}	9.3 ± 0.5^{bB}	9.0 ± 0.6^{bcBC}	8.9 ± 0.8^{cC}
Bi-malleolare	7.4 ± 0.4^{aA}	7.1 ± 0.4^{aA}	6.9 ± 0.4^{bB}	6.8 ± 0.6^{bB}
Girths (cm)				
Forearm	23.7 ± 1.7^{aA}	22.0 ± 1.6^{bB}	21.1 ± 1.6^{cC}	20.8 ± 1.9^{cC}
Relaxed arm	25.0 ± 2.2^{aA}	22.3 ± 2.2^{bB}	21.5 ± 2.0^{bcBC}	21.0 ± 2.2^{cC}
Flexed arm	27.0 ± 2.2^{aA}	24.3 ± 2.7^{bB}	23.5 ± 2.5^{bcBC}	22.9 ± 2.3^{cC}
Calf	33.4 ± 2.5^{aA}	31.4 ± 2.8^{bB}	30.1 ± 2.4^{cC}	29.4 ± 2.8^{cC}
Thigh	49.4 ± 3.8^{aA}	46.0 ± 5.3^{bB}	44.6 ± 3.9^{bcBC}	43.5 ± 4.8^{cC}
Body composition				
TR + SS (mm)	19.9 ± 8.1^{aA}	17.7 ± 5.7^{aA}	16.5 ± 6.5^{abAB}	14.3 ± 4.8^{bB}
Σ_{11SF} (mm)	114.7 ± 44.7^{aA}	96.6 ± 32.6^{abAB}	90.5 ± 37.9^{bcBC}	79.2 ± 30.2^{cC}
%Fat	17.0 ± 6.7^{aA}	15.3 ± 5.1^{aA}	14.0 ± 5.7^{abAB}	12.1 ± 4.5^{bB}
LBM (kg)	43.3 ± 6.7^{aA}	38.0 ± 7.8^{bB}	34.1 ± 5.8^{cC}	33.3 ± 7.4^{cC}
UAMA (cm^2)	36.0 ± 6.2^{aA}	28.9 ± 6.8^{bB}	27.2 ± 5.3^{bB}	26.9 ± 6.3^{bB}
Endomorphy	2.7 ± 1.2^{aA}	2.3 ± 0.9^{abAB}	2.1 ± 1.0^{bcBC}	1.8 ± 0.8^{cC}
Mesomorphy	4.6 ± 1.0^{aA}	4.3 ± 0.9^{aA}	4.5 ± 0.8^{aA}	4.4 ± 0.9^{aA}
Ectomorphy	3.7 ± 1.0^{aA}	3.7 ± 1.1^{aA}	3.6 ± 1.0^{aA}	3.6 ± 0.9^{aA}

Different lower case letters indicate statistically significant differences ($p < .05$) in comparisons between field positions. Different upper case letters indicate significant effect size (ES > .5) in comparisons between field positions

BMI body mass index, *Bi-humeral and Bi-femoral* humeral biepicondylar and femoral biepicondylar diameters, respectively, *TR* triceps skinfold, *SS* subscapular skinfold, $\sum_{11SF}$ sum of the 11 skinfolds, *%Fat* body fat percentage, *LBM* lean body mass, *UAMA* upper arm muscularity area

The most highlighted somatotype characteristic in soccer players in this age group seems to be mesomorphy, as opposed to endomorphy. These findings were also observed by other studies with children [23, 25] and adults [8, 23, 25], although some have found predominance of endomorphy at 12 years of age [25]. Low endomorphy is associated to high energy expenditure from intense sports practice and adequate adiposity in these athletes. Because of that, probably, Reilly et al. [8] have noticed that in elite versus non-elite athletes, mesomorphy was the predominant component of somatotype.

Table 2 Physical fitness characteristics of soccer players by field position

	Goalkeepers	Defenders	Midfielders	Forwards
n	26	77	113	80
Physical fitness				
Handgrip (kg)	57.1 ± 12.8^{aA}	51.9 ± 13.8^{aA}	46.0 ± 11.0^{bB}	43.9 ± 12.9^{bB}
EF (kg)	34.7 ± 11.9^{aA}	30.2 ± 7.1^{aA}	29.5 ± 7.4^{aA}	26.8 ± 8.2^{aA}
KE (kg)	121.1 ± 30.9^{aA}	102.2 ± 25.6^{bB}	92.3 ± 23.7^{bB}	91.5 ± 21.1^{bB}
Sit-ups (rep)	46.7 ± 8.1^{aA}	43.0 ± 7.7^{aA}	47.1 ± 5.8^{aA}	44.5 ± 6.9^{aA}
S & R (cm)	33.8 ± 7.3^{aA}	28.4 ± 5.9^{bB}	28.6 ± 5.6^{bB}	28.3 ± 5.3^{bB}
VJ (cm)	43.6 ± 5.2^{aA}	40.8 ± 7.1^{abAB}	40.0 ± 7.5^{abAB}	38.6 ± 6.7^{bB}
Agility (s)	9.75 ± 0.52^{aA}	9.82 ± 0.45^{aA}	9.78 ± 0.54^{aA}	9.74 ± 0.51^{aA}
VO_{2max} (ml/kg/min)	57.5 ± 3.0^{aA}	58.5 ± 3.5^{aA}	58.5 ± 3.5^{aA}	57.7 ± 3.8^{aA}

Different lower case letters indicate statistically significant differences ($p < .05$) in comparisons between age groups. Different upper case letters indicate significant effect size (ES > .5) in comparisons between field positions

Handgrip sum of the strength of left and right hand, *EF* elbow flexion, *KE* knee extension, *Sit-ups* 1 min sit-ups, *S & R* sit-and-reach, *VJ* vertical jump

Literature shows that, among children, adolescents and adults soccer players, VO_{2max} varies between 50 and 75 ml/kg/min [1]. Seen in these terms, values verified in the present study are strictly placed within this range, and are similar to the ones found by other authors [1, 9, 24], but they are not higher than the ones registered by others [1, 11]. Regarding field positions, as in the present study, some did not show significant differences, both in adults [1, 8], and in children (over 13 years of age) [1]. Conversely, some studies have verified the VO_{2max} of midfielders and forwards to be superior to the one of the goalkeepers [1, 2, 9, 23, 24] and defenders [1, 24]. Although there is no complete agreement concerning VO_{2max}, differences potentially reflect the characteristics and specificities of each field position, as goalkeepers perform an essentially anaerobic alactic function, and defenders cover shorter distances during matches [1, 3–5, 14, 26]. It is also likely that these differences reflect the level of athletes' professionalism, which results in more weekly hours and days dedicated to training, as well as the recruitment trials. The use of the allometric scale adds the influence of lean mass. For that reason, results of the goalkeepers and defenders were significantly higher than the ones of the other players.

Results of handgrip strength and lower limb power of participants from this study revealed that goalkeepers and defenders are stronger than all the others, which could be explained by the higher lean mass and muscularity of these athletes. On the order hand, the influence of muscle mass did not affect local muscle resistance (abdominal anaerobic capacity). Literature is inconclusive regarding muscle strength. Some data show that goalkeepers and midfielders are stronger than forwards in 1 RM bench press test [7], even that goalkeepers, defenders and forwards are stronger than midfielders [1]. The lack of consistency in available data makes it hard to draw any practical conclusion.

As for flexibility, Nikolaidis [27] have noticed that values of sit-and-reach test increased according to boys' age, from 10 to 18 years, remaining stable from 18 to adult phase. Regarding field positions, data from adults do not indicate significant differences [2, 7], except in the case of goalkeepers, that present a higher range of movement in hip and knee than the other players [2]. Same behaviour was perceived in the present study: goalkeepers exhibited higher flexibility than all the other boys from other positions.

Muscle power, especially in lower limbs is an important component of soccer players' physical fitness [1]. Goalkeepers from our sample demonstrated significant higher values of vertical jump than forwards, but not higher values than athletes from other positions. Using vertical jump as an indicator in adults, Stolen et al. [1] did not find significant differences among field positions. Likewise, Malina et al. [6] also did not find differences in vertical jump among 13–15-year-old defenders, midfielders and forwards. On the other hand, Lago-Peñas et al. [24] evaluated players ageing 12–19 years, and despite not finding significant differences, they observed that goalkeepers presented the best performance in vertical jump when compared to other players.

Regarding agility, we did not observe significant differences among field positions. Vanderford et al. [11] evaluated a group of young athletes from youth categories under-14, under-15 and under-16 and attributed the perceived changes in agility much more to maturation than to the specificity of field position of this physical capacity. A study with adults found similar results [7]. Regarding the associations between agility, strength and muscle power verified by other authors [12], our data indicate that these associations were weak when comparing agility and strength, but moderate when agility was associated to muscle power.

The fact that this sample represents the elite of Brazilian soccer in this age group imposes a natural limitation to the extrapolation of our data to other populations. Besides, as we did not consider aspects of boys' maturation, it is not possible to discard the fact that maturation itself could influence results. We observed this phenomenon in a recent publication [28]. As soccer player boys grow older, they exhibit more muscularity associated to higher strength, power, agility and VO_{2max} [29]. Future research should use cross-sectional data like the ones from the present study combined to longitudinal data, making it possible to identify milestones in growth, body composition and physical fitness development of young athletes.

Comparisons of anthropometry and physical fitness characteristics of young athletes from other teams worldwide with our data may be useful for coaches. Moreover, as each field position has characteristics that demand appropriate anthropometric and physical fitness features, data from this large sample of young athletes, from a three times South-American and world champion soccer team may serve a reference in recruitment and field position assignment.

Conclusions

Our data show clear differences among athlete children from different field positions. Despite the few differences in agility and maximal oxygen consumption, goalkeepers and defenders from an elite international soccer club are taller, heavier, and have more lean mass than midfielders and forwards. Goalkeepers have more flexibility, lower limb strength and muscle power than players from other field positions. Forwards, conversely, present lower adiposity than athletes from all other positions.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study were approved by local ethics committee and were in accordance with the national ethical standards and with the 1964 Helsinki declaration and its later amendments.

Informed consent Informed written consent was obtained from all parents/guardians of participants included in the study.

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