ARTIGO ORIGINAL

Anthropometric and physical fitness characteristics of young male soccer players

Características antropométricas e de aptidão física de meninos atletas de futebol

Ive Luz Canhadas [1]
Rodrigo Lopes Pignataro Silva [2]
Celso Rodrigures Chaves [3]
Leslie Andrews Portes [4]

1 Enfermeira no Hospital e Maternidade Alvorada, São Paulo, SP. Brasil.

2 Centro Universitário Adventista de São Paulo. Curso de Educação Física. Categorias de Base do São Paulo Futebol Clube. São Paulo, SP. Brasil.

3 Centro Universitário Adventista de São Paulo. Curso de Educação Física. São Paulo, SP. Brasil.

4 Universidade Federal de São Paulo. Laboratório de Fisiologia e Fisiopatologia cardíaca. Centro Universitário Adventista de São Paulo. Laboratório de Fisiologia do Exercício. São Paulo, SP. Brasil.

Recebido em 23/07/09
Revisado em 10/08/09
Aprovado em 22/01/10

Resumo – O presente estudo teve por objetivo determinar as características antropométricas e de aptidão física de meninos no início da fase de treinamento especializado em futebol. Foram avaliados 282 meninos atletas de 10 a 13 anos de idade. Os meninos atletas estavam na fase inicial do treinamento especializado, 3 vezes/semana, 3 horas/dia. Todos foram submetidos a testes e medidas antropométricas e de aptidão física. Os meninos atletas foram agrupados em faixas etárias e os dados relativos às prevalências nas diferentes categorias antropométricas e de composição corporal foram analisados por meio do teste do qui-quadrado de Pearson. Os dados paramétricos foram comparados por meio da ANOVA one-way e, quando necessário, por meio do método de Kruskal-Wallis. Todos os resultados foram expressos como média±desvios-padrão e os resultados foram considerados estatisticamente diferentes quando p<0,05. O crescimento, o desenvolvimento, a adiposidade corporal e a aptidão física foram adequadas e proporcionais à idade dos meninos atletas de futebol (p<0,05). Concluiu-se que as características antropométricas e de aptidão física de meninos das categorias de base da elite do futebol melhoram e são proporcionais à idade. Crianças e adolescentes atletas de futebol exibem favoráveis características antropométricas e de aptidão física.
Palavras-chave: Futebol; Crescimento; Desenvolvimento infantil; Aptidão Física.

Abstract – *The objective of this study was to determine anthropometric and physical fitness characteristics of Brazilian male children and adolescents at the beginning of soccer training. In this study, 282 male soccer players ranging in age from 10 to 13 years were evaluated. The athletes participated in a formal soccer training program 3 times per week, with each training lasting 3 hours. Anthropometric and physical fitness parameters were obtained. The boys were divided into age classes and prevalence data were analyzed using Pearson's chi-square test. Parametric data were compared by one-way ANOVA or the Kruskal-Wallis test, when necessary. The results are expressed as the mean ± standard deviation and a p value <0.05 was considered to be significant. Growth, development, body adiposity and physical fitness characteristics were adequate and proportional to age among the boys studied (p<0.05). It was concluded that anthropometric and physical fitness characteristics of young male elite soccer players improve with and are proportional to age. Children and adolescents greatly benefit from regular physical activity. The present results show that young male soccer players present adequate anthropometric conditions and physical fitness prior to the initiation of formal training at soccer clubs.*
Key words: *Soccer; Growth; Child development; Fitness.*

INTRODUCTION

The number of children and adolescents encouraged to participate in intense physical training and elite competitive activities has increased over the years[1,2]. This fact is observed particularly among Brazilian children and adolescents, who search for soccer schools having in mind a future as elite athletes. This phenomenon can be explained, in part, by the success of Brazilian athletes around the world and numerous world titles, as well as by the fact that many athletes leave the country and obtain financial independence.

Physical activity is generally considered to be necessary for adequate growth and development[1-4]. Many studies have ruled out a negative effect of physical training on growth and development[1-6], although evidence indicates that early excessive physical training in some sport disciplines might be detrimental[2,3,5,7]. Although the effects of physical training during this phase of life are difficult to distinguish from those of normal growth and development[1,2,5], studies have shown a significant increase in maximum oxygen consumption (VO_{2max})[2,5,8-10] and running economy[2,8], an increase in the strength of various muscle groups[2,5,11,12], an increase in lower limb muscle power and running velocity[5,12], an increase in bone mineral content and back and hamstring flexibility[12], and a reduction in body adiposity[5,12]. These benefits have been identified and attributed to training in sport disciplines such as Gaelic football and hurling[13], long-distance running[10], gymnastics[7,14], swimming[14], tennis[15,16], and soccer[6,8,9,11-13]. Studies conducted on Brazilian child and adolescent soccer players have demonstrated normal growth and development[6,8], no negative influence of soccer training on somatotype[6], a higher VO_{2max} in trained subjects[8], and normal physiological and metabolic responses to anaerobic exercise[17,18]. The hypothesis is that, at this age, male elite soccer players present adequate growth, development and physical fitness characteristics before the initiation of formal soccer training.

The objective of the present study was to analyze anthropometric and physical fitness characteristics of male children and adolescents at the beginning of soccer training. This information, together with previous findings showing adequate soccer training responses during growth and development of children and adolescents, will assist pediatricians and other health professionals to better understand and monitor anthropometric, morphological and physiological variations in male athletes during the phase of growth and development.

METHODOLOGY

Participants

The sample consisted of young male athletes ranging in age from 10 to 13 years, who are part of a player development program of one of the most important soccer clubs in Brazil. All boys participating in this program are selected based on their height and their ability to play soccer. During the selection process, hundreds of boys from different parts of Brazil, especially Sao Paulo, are evaluated and selected by coaches of the soccer club. The boys selected during this phase present the adequate biological characteristics to play in all soccer positions: goalkeeper, defender, midfielder, or forward. After the selection process, the boys are enrolled in a training program developed by the soccer club, which consists of training three times per week for 3 hours/day. **The parents or guardians of the boys were adequately informed about the study and gave written consent to the soccer club** and the club agreed to the participation of the children in the evaluation described below as a part of the routine exams performed by the club. All procedures were performed according to the guidelines of the Helsinki Declaration of Human Rights (www.wma.net/e/policy/b3.htm) and were in accordance with the 196/97 resolution of the Brazilian Ministry of Health. The study was approved by the Ethics Committee of the Adventist University of Sao Paulo (UNASP).

Anthropometry

The anthropometric measurements were made according to the protocols recommended by different investigators[19-23]. Height was measured with an appropriate stadiometer to the nearest 0.1 cm. Body weight was obtained with a digital scale (Filizola, Sao Paulo, Brazil) to the nearest 0.1 kg, with the boys wearing only shorts[19]. Body adiposity was estimated by the measurement of skinfold thicknesses to the nearest 1 mm using a Lange skinfold caliper. The following skinfold measurements were obtained: lateral forearm, medial forearm, biceps, triceps, subscapular, iliac crest, supraspinal, abdominal, front thigh, medial calf, and popliteal[20]. Each skinfold was measured three times and the median value was used for calculation. Forearm girth, relaxed arm girth, flexed and tensed arm girth, and thigh and calf girth were obtained to the nearest 0.1 cm using a flexible fiber tape. Bone breadths: humerus bi-epicondylar, wrist bistyloid, femur bi-epicondylar and bi-malleolus were determined to the nearest 0.1

cm using a 30-cm anthropometer (Lafayette Instrument Company, Lafayette, IN, USA)[20].

Body composition was evaluated based on the following variables: percent body fat (%fat), lean body mass, muscularity[21], and Heath-Carter somatotype[23]. Percent fat was estimated using the equations of Slaughter et al.[20] as the sum of triceps (TR) and subscapular (SS) skinfolds[25] [boys with a sum < 35 mm: %fat = 1.21 x (TR + SS) – 0.008 x $(TR + SS)^2$ – 3.4; boys with a sum ≥ 35 mm: %fat = 0.783 x (TR+SS) + 1.6]. Body fat weight was calculated as follows: fat weight = %fat x weight / 100. Lean body mass was determined by subtracting body fat weight from total body weight. Muscularity (cm^2) was estimated using the following equation[21]: $[\text{arm circumference} – (p \times TR)]^2/4p$. The Heath-Carter somatotype was calculated as described by Carter[23]. Additionally, the body mass index (BMI) was calculated as weight divided by the square of the height.

Growth and development were evaluated by dividing the boys into three groups according to height-for-age and weight-for-age curves. Weight was considered to be low if below the 3rd percentile; height and weight between the 3rd and 97th percentile were defined as adequate, and height and weight above the 97th percentile were considered to be high[24]. The boys were also divided into groups according to the four BMI categories (low BMI: values below the 5th percentile; adequate BMI: values between the 5th and 85th percentile; overweight: values between the 85th and 95th percentile; obesity: values above the 95th percentile)[24]. Finally, the boys were divided into four groups according to %fat (underweight: %fat less than 10%; adequate adiposity: %fat between 10% and 20%; excess body fat: %fat between 20% and 25%; obese: %fat higher than 25%)[22].

Physical fitness

Physical fitness was determined using the following tests: 1) isometric strength: handgrip, knee extension and elbow flexion[26], 2) agility: shuttle-run[19], 3) back and hamstring flexibility: sit-and-reach test of Wells and Dillon[19], 4) lower limb power: vertical jump[26], and 5) 1,000-m run/walk test to estimate VO_{2max}[19].

Isometric grip strength was measured with a Jamar isometric dynamometer to the nearest 0.1 kg (Bolingbrook, IL). Isometric strength of knee extension and elbow flexion were obtained to the nearest 0.1 kg using the Takei Physical Fitness Test dynamometer. After specific stretching and warm-up, the boys made one or two attempts to become familiar with the equipment. Next, three maximal attempts were performed, with an interval of 60 seconds between attempts, and the best result was used for analysis.

Agility was determined by measuring the time necessary for the subject to alternately pick up two small wooden objects (5 x 5 x 10 cm), covering a distance of 9.15 m. Back and hamstring flexibility was evaluated by the sit-and-reach test. The maximum distance reached (cm), with one hand parallel to the other and the knees extended, was used as an indicator of back and hamstring flexibility. Lower limb power was measured by the vertical jump test, with assistance of the upper limbs and trunk movement. The difference between the highest point reached after jumping and total height was used as an indicator of lower limb power. In the agility, flexibility and vertical jump tests the subjects made three attempts and the best result obtained in the tests was used for analysis.

Cardiorespiratory fitness was determined by calculating VO_{2max} after the 1,000-m run/walk test. The time spent (in seconds) 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

All results are expressed as the mean ± standard deviation. The boys were divided into groups according to age. Categorized variables (height, weight, BMI and %fat percentiles) were analyzed using Pearson's chi-square test. Parametric data were compared by one-way ANOVA or the Kruskal-Wallis test, when necessary. The results were considered to be significantly different when $p < 0.05$. The SigmaStat 3.5 for Windows statistical package (www.Systat.com) was used for analysis.

RESULTS

A total of 282 young male soccer players were evaluated (Table 1). The boys' height increased significantly with age as expected, whereas a significant difference in body weight was only observed between 13-year-old boys and the other age groups ($p \leq 0.001$). The BMI of 13-year-old boys was significantly higher than that of 11-year-old boys ($p = 0.003$). No significant difference in skinfold thickness was observed between age groups, except for subscapular skinfold thickness which was significantly lower in 11-year-old boys compared to 10- and 13-year-old boys ($p = 0.047$). ANOVA also revealed an increase in bone diameter with age, but statistically significant differences ($p \leq 0.001$) were only observed for 12-year-old boys (bistyloid and humeral biepicondylar diameters) and 13-year-old boys (bi-styloid and femoral bi-epicondylar diameters). Girth measurements increased with age, but statistically significant differences were only observed for 12-year-old boys (forearm and relaxed arm girths) and 13-year-old boys (flexed arm, leg and thigh girths).

The results regarding body composition and somatotype are summarized in Table 2. Adiposity, evaluated based on the sum of TR and SS skinfolds, sum of 11 skinfolds (Σ_{11SF}) and %fat, did not differ significantly between the age groups studied. Lean body mass was significantly higher in 13-year-old boys when compared to the other participants ($p \leq 0.001$). Arm muscularity increased with age: 10 years = 11 years = 12 years < 13

Table 1. Anthropometric characteristics of young male soccer players.

	10 years	11 years	12 years	13 years
N	14	51	121	96
Height (cm)	140.6± 8.2 [a]	143.9±8.0 [a]	150.5 ±8.2 [b]	158.2±10.4 [c]
Weight (kg)	34.7± 7.0 [a]	35.9±6.2 [a]	40.4±7.8 [a]	46.5±10.1 [b]
BMI (kg/m²)	17.4± 2.2 [ab]	17.2±1.7 [a]	17.7±2.1 [ab]	18.3±1.9 [b]
		Skinfold (mm)		
Lateral forearm	7.5± 3.1 [a]	6.7±2.5 [a]	6.9±2.7 [a]	6.2±2.4 [a]
Medial forearm	5.9± 2.8 [a]	5.2±2.3 [a]	5.4±2.5 [a]	4.8±2.1 [a]
Biceps	5.4± 2.2 [a]	5.1±2.3 [a]	5.4±2.8 [a]	4.5±2.3 [a]
Triceps	10.3± 3.1 [a]	9.4±4.2 [a]	10.5±4.8 [a]	9.5±4.1 [a]
Subscapular	7.0± 3.2 [a]	6.0±2.3 [b]	6.5±2.4 [ab]	6.9±2.2 [a]
Iliac crest	12.1± 5.9 [a]	10.1±6.7 [a]	10.8±6.1 [a]	10.6±5.3 [a]
Supraspinal	6.2± 3.4 [a]	5.1±2.7 [a]	5.9±3.0 [a]	5.9 ±2.7 [a]
Abdominal	9.1± 5.2 [a]	7.8±4.1 [a]	8.9±5.6 [a]	8.5±4.3 [a]
Front thigh	18.2± 6.6 [a]	15.3±6.8 [a]	15.4±6.8 [a]	13.7±5.3 [a]
Medial calf	10.2± 3.5 [a]	9.8±4.1 [a]	9.8±4.4 [a]	9.7±4.4 [a]
Popliteal	8.2± 2.6 [a]	8.2±3.6 [a]	7.9±3.8 [a]	8.0±4.2 [a]
		Bone breadth (cm)		
Humerus	5.8± 0,5 [a]	5.8±0.5 [a]	6.1±0.4 [b]	6.4±0.6 [c]
Wrist (bistyloid)	4.6± 0.4 [a]	4.6±0.4 [a]	4.8±0.4 [b]	5.1±3.4 [c]
Femur	8.6± 0.7 [a]	8.8±0.6 [a]	9.0±0.5 [a]	9.3±0.7 [b]
Bi-malleolus	6.6± 0.4 [a]	6.7±0.5 [a]	6.9 ±0.4 [a]	7.1±0.6 [b]
		Girth (cm)		
Forearm	20.6± 1.7 [ab]	20.5±1.6 [a]	21.3±1.6 [b]	22.3±1.9 [c]
Relaxed arm	20.9± 2.2 [ab]	20.6±1.9 [a]	21.7±2.2 [b]	22.8±2.4 [b]
Flexed arm	22.6± 2.5 [a]	22.6±2.7 [a]	23.5±2.2 [a]	25.1±2.8 [b]
Calf	28.6± 2.7 [a]	29.3±2.4 [a]	30.2±2.6 [a]	31.6±2.7 [b]
Thigh	42.2± 4.3 [a]	42.9±3.7 [a]	44.6±4.6 [a]	46.8±4.8 [b]

Different superscript letters indicate statistically significant differences between age groups ($p < 0.05$).

Table 2. Body composition and somatotype of young male soccer players.

	10 years	11 years	12 years	13 years
TR + SS (mm)	17.3±5.7 [a]	15.4±6.2 [a]	16.9±6.8 [a]	16.3±5.7 [a]
Σ_{11SF} (mm)	84.5±31.9 [a]	74.1±31.1 [a]	78.6±33.5 [a]	74.2±27.7 [a]
%Fat	14.8±5.1 [a]	13.1±5.6 [a]	14.5±5.8 [a]	13.9±5.2 [a]
LBM (kg)	29.4±5.1 [a]	30.9±4.3 [a]	34.3±5.9 [a]	39.7±7.9 [b]
Muscularity (cm²)	25.2±4.9 [a]	24.8±3.9 [a]	27.0±5.5 [a]	31.8±7.3 [b]
Endomorphism	2.3±0.9 [a]	1.9±0.9 [a]	2.2±1.1 [a]	2.2±0.9 [a]
Mesomorphism	4.8±0.8 [a]	4.5±0.9 [a]	4.4±0.8 [a]	4.3±0.8 [a]
Ectomorphism	3.2±1.1 [a]	3.5±0.9 [a]	3.8±1.1 [a]	3.8±0.9 [a]

TR: triceps skinfold. SS: subscapular skinfold. $\sum_{11SF}$: sum of 11 skinfolds. LBM: lean body mass. Different superscript letters indicate statistically significant differences between age groups ($p < 0.05$).

years ($p \leq 0.001$). Somatotype analysis of the 282 male athletes showed a predominance of mesomorphism in all age groups, followed by ectomorphism, findings indicating a predominant development of muscle and bone tissues, respectively. No significant differences in the three somatotype components were observed between the different age groups.

The results of the physical fitness tests are summarized in Table 3. Handgrip strength and strength of knee extension were significantly higher ($p \leq 0.004$) in 13-year-old boys compared to the other groups. Thirteen-year-old boys were also significantly stronger than 10- and 11-year-old boys in the elbow flexion exercise. No difference in back or hamstring flexibility was observed between groups. Lower limb power was greater in 12- and 13-year-old boys compared to 10- and 11-year-old boys ($p \leq 0.001$). The results of the agility test indicated a significant increase in agility with age ($p \leq 0.001$). Finally, VO_{2max} increased significantly with age ($p < 0.001$): 10 years < 11 years < 12 years < 13 years.

In order to better understand the influence of age on the muscle strength of young male athletes in the age groups studied, the values of the different tests were divided by the respective lean body mass and by the level of muscularity (Figure 1). No significant differences in the different strength/lean body mass ratios were observed between age groups.

Growth and development data

Table 4 summarizes the results regarding the classification of young male soccer players according to growth (height) and development curves (weight and BMI) and body adiposity. Almost all boys showed adequate growth and development for their age. Height, weight and BMI values below the average for age were only observed in 1%, 3% and 4% of the boys, respectively. There was a low incidence of obesity and excess body fat as expected for boys participating in this sport modality; however, 20% of the participants were classified as thing.

Table 4. Distribution of young male soccer players according to the different anthropometric categories

Category	Parameter	
Anthropometry	Height	Weight
Percentile < 3	4 (1%)	9 (3%)
Percentile 3-97	253 (90%)	269 (96%)
Percentile > 97	25 (9%)	4 (1%)
	BMI	
Percentile < 5	11 (4%)	
Percentile < 85	252 (89%)	
Percentile < 95	18 (6%)	
Percentile ≥ 95	1 (1%)	
% Body fat		
< 10%	56 (20%)	
< 20%	181 (64%)	
< 25%	31 (11%)	
≥ 25%	14 (5%)	

Table 3. Physical fitness of young male soccer players.

	10 years	11 years	12 years	13 years
Handgrip (kg)	37.7±7.3 ^{a}	40.5±6.2 ^{a}	46.1±10.1 ^{a}	54.4±15.5 ^{b}
Elbow flexion (kg)	23.0±4.5 ^{a}	25.7±7.6 ^{a}	28.7±6.2 ^{ab}	32.6±9.2 ^{b}
Knee extension (kg)	79.1±14.4 ^{a}	87.8±20.8 ^{a}	92.2±24.1 ^{a}	109.7±29.1 ^{b}
Flexibility (cm)	27.5±5.2 ^{a}	28.2±4.2 ^{a}	27.7±6.4 ^{a}	30.5±6.5 ^{a}
Vertical jump (cm)	36.1±5.9 ^{ab}	35.2±4.9 ^{a}	40.1±6.2 ^{b}	42.9±7.8 ^{b}
Agility (seconds)	10.00±0.52 ^{a}	10.19±0.50 ^{a}	9.82±0.42 ^{b}	9.48±0.43 ^{c}
VO_{2max} (ml/kg/min)	52.3±5.2 ^{a}	56.7±2.6 ^{b}	58.1±3.1 ^{c}	60.4±2.7 ^{d}

Handgrip: sum of the strength of the left and right hand. Different superscript letters indicate statistically significant differences ($p < 0.05$) between age groups.

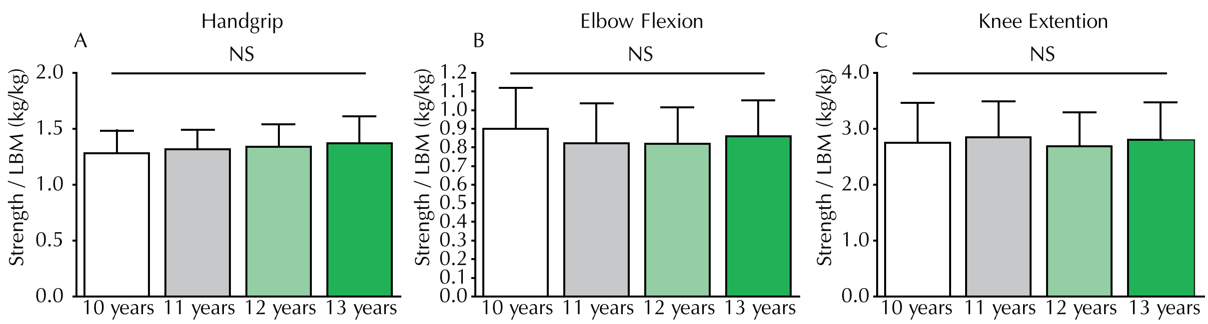

Figure 1. Isometric handgrip strength (A), strength of elbow flexion (B) and strength of knee extension (C) in relation to lean body mass (LBM) in 10- to 13-year-old male soccer players. NS: not significant.

DISCUSSION

The popularity of soccer and Brazilian soccer players and the elevated financial gain explain, in part, the large number of children and adolescents engaged in professional soccer training. Children and their parents seek the main soccer clubs in the country, where these children are subjected to training programs that may impair normal growth and development. There are frequent reports of players requiring surgery early in life because of excessive training and games. Curiously, little is known about the physical and functional characteristics of Brazilian children and adolescents selected to participate in professional training during this phase of growth and development[6,8,17,18].

Anthropometric profile

In the present large sample of child and adolescent soccer players, the indicators of growth and development before soccer training – height, weight, and BMI – were normal in 99%, 96% and 96% of the boys, respectively. These results demonstrate that boys selected for soccer training present adequate growth and developmental characteristics[6,8,27], and agree with similar studies on different sport disciplines such as gymnastics[4,7,28], handball[4,28], swimming[4,28], and tennis[16]. It is important to note that four (1%) of the boys studied were below the 3rd percentile for height, nine (3%) were below the 3rd percentile for body weight, 11 (4%) were below the 5th percentile for BMI, and 56 (20%) were classified as thin according to %fat. These results are probably associated with the level of training intensity[13,28], the selection before soccer training[28], or physical activities performed by these children and adolescents[3,5,28]. It seems to be clear that the higher energy expenditure of athlete boys prior to the selection for formal soccer training contributed to the body composition results during this phase of life. Furthermore, these aspects, associated with genetic characteristics, determine the different biotypes of boys. These data reinforce the importance of engagement in physical activity for an adequate anthropometric profile and body composition.

The significant increases in bone diameters, girths, lean body mass and muscularity with age also support the notion that the boys presented adequate growth and development for their age. The observation that lean body mass and muscularity increased with age and that the ratio between strength/lean body mass and strength/muscularity increased proportionally with age indicates that the protein-calorie intake was adequate for age[1-3,5,11,12].

Physical fitness

In general, studies have ruled out a negative effect of physical training on growth and development[1-6], although evidence indicates that early excessive physical training in some sports may be detrimental[2,3,5,7]. The effects of physical training during this phase of life are difficult to distinguish from those of normal growth and development[1,2,5], but studies have shown a significant increase in VO_{2max}[2,5,8-10,29] and running economy[2,8], an increase in the strength of various muscle groups[2,5,11,12], an increase in lower limb muscle power and running velocity[5,12], an increase in bone mineral content and back and hamstring flexibility[12], and a reduction in body adiposity[5,12]. These benefits have been identified and attributed to training in various sport disciplines such as Gaelic football and hurling[13], long-distance running[10], gymnastics[7,14], swimming[14], tennis[15,16], and soccer[6,8,9,11-13,15]. Studies conducted on Brazilian child and adolescent soccer players demonstrated normal growth and development[6,8], a normal somatotype[6], higher VO_{2max}[8], and normal physiological and metabolic responses to anaerobic exercise[17,18].

The findings of this investigation are in agreement with those reported in previous similar studies. Boys aged 10 to 13 years selected for formal soccer training present anthropometric and physical fitness characteristics that are adequate for their age. In addition, VO_{2max} increased with age as also observed by other investigators[15], a finding that can be attributed to pubertal maturation. The VO_{2max} values obtained in this study were on average equal to or lower than 60 ml/kg/min. These values are considered to be appropriate for boys of this age[9], are higher than those obtained for non-athlete boys[29], and are slightly higher than the values reported by other investigators for Brazilian boys in the same phase of maturation[8].

CONCLUSION

The present study demonstrated that the growth, development, body composition, biotype characteristics and physical fitness of young male elite soccer players improve with and are proportional to age. The results support the view that children and adolescents greatly benefit from regular physical activity. Finally, the present results show that young male soccer players present adequate anthropometric conditions and physical fitness prior to the initiation of formal training at soccer clubs.

Acknowledgments

The authors thank all children and adolescents who participated in this study and the Sao Paulo Soccer Club. Special thanks are due to Ms. Lynne Portes Vaz for the revision of English language and style.

REFERENCES

1. Maffulli N. The growing child in sport. Br Med Bull 1992;48:561-8.
2. Naughton G, Farpour-Lambert NJ, Carlson J, Bradney M, Van Praagh E. Physiological issues surrounding the performance of adolescent athletes. Sports Med 2000;30:309-25.
3. Rogol AD, Clark PA, Roemmich JN. Growth and pubertal development in children and adolescents: effects of diet and physical activity. Am J Clin Nutr 2000;72(Suppl.):521S-8S.
4. Damsgaard R, Bencke J, Matthiesen G, Petersen JH, Müller J. Is prepubertal growth adversely affected by sport? Med Sci Sports Exerc 2000;32:1698-703.
5. Malina RM. Anthropometry, strength and motor fitness. In: Ulijaszek SJ, Mascie-Taylor CGN, editors. Anthropometry: The Individual and the Population. Cambridge, UK: Cambridge University Press, 1994, pp. 160-177.
6. Mortatti AL, Arruda M. Análise do efeito do treinamento e da maturação sexual sobre o somatotipo de jovens futebolistas. Rev Bras Cineantropom Desempenho Hum 2007;9:84-91.
7. Caine D, Lewis R, O'Connor P, Howe W, Bass S. Does gymnastics training inhibit growth of females? Clin J Sport Med 2001;11:260-70.
8. Stabelini Neto A, Mascarenhas LP, Bozza R, Ulbrich AZ, Vasconcelos IQ, Campos W. VO_2 máx. e composição corporal durante a puberdade: comparação entre praticantes e não praticantes de treinamento sistematizado de futebol. Rev Bras Cineantropom Desempenho Hum 2007;9:159-64.
9. Stolen T, Chamari K, Castagna C, Wisloff U. Physiology of soccer. Sports Med 2005;35:501-66.
10. Rowland TW, Boyajian A. Aerobic response to endurance exercise training in children. Pediatrics 1995;96:654-8.
11. Hansen L, Bangsbo J, Twisk J, Klausen K. Development of muscle strength in relation to training level and testosterone in young male soccer players. J Appl Physiol 1999;87:1141-7.
12. Vicente-Rodriguez G, Jimenez-Ramirez J, Ara I, Serrano-Sanchez JA, Dorado C, Calbet JA. Enhanced bone mass and physical fitness in prepubescent footballers. Bone 2003;33:853-9.
13. McIntyre MC. A comparison of the physiological profiles of elite Gaelic footballers, hurlers, and soccer players. Br J Sports Med 2005;39:437-9.
14. Bencke J, Damsgaard R, Saekmose A, Jorgensen P, Jorgensen K, Klausen K. Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. Scand J Med Sci Sports 2002;12:171-8.
15. Baxter-Jones A, Goldstein H, Helms P. The development of aerobic power in young athletes. J Appl Physiol 1993;75:1160-7.
16. Kanehisa H, Kuno S, Katsuta S, Fukunaga T. A 2-year follow-up study on muscle size and dynamic strength in teenage tennis players. Scand J Med Sci Sports 2006;16:93-101.
17. Mantovani TVL, Rodrigues GA, Miranda JM, Palmeira MV, Abad CC, Wichi RB. Composição corporal e limiar anaeróbio de jogadores de futebol das categorias de base. Rev Mackenzie de Educação Física e Esporte 2008;7:25-33.
18. Coelho DB, Mortimer LA, Condessa LA, Soares DD, Barros CL, Garcia ES. Limiar anaeróbio de jogadores de futebol de diferentes categorias. Rev Bras Cineantropom Desempenho Hum 2009;11:81-7.
19. Matsudo VKR, editor. Testes em Ciências do Esporte. São Caetano do Sul: CELAFISCS, 1984.
20. Eston R, Reilly T, editors. Kinanthropometry and Exercise Physiology Laboratory Manual: Tests, Procedures and Data. Volume 1: Anthropometry. 2nd ed., New York: Routledge, Taylor & Francis Group, 2001.
21. Jelliffe EEP, Jelliffe DB. The arm circumference as a public health index of protein-calorie malnutrition of early childhood. J Trop Pediatr 1969;15:179-92.
22. Lohman TG. The use of skinfold to estimate body fatness on children and youth. JPERD 1987;58(9):98-102.
23. Carter JEL. The Heath-Carter Anthropometric Somatotype – Instruction Manual. San Diego, CA, 2002. Available at: http://www.somatotype.org/Heath-CarterManual.pdf. Accessed January 2006.
24. Eisenstein E, Coelho KS, Coelho SC, Coelho MA. Nutrição na Adolescência. J Pediatr (Rio J.) 2000;76(Supl.3):S263-74.
25. Owen GM. Measurement, recording, and assessment of skinfold thickness in childhood and adolescence: report of small meeting. Am J Clin Nutri 1982;35:629-38.
26. Adams GM. Exercise Physiology Laboratory Manual. 3rd ed. Dubuque: Brown & Benchmark Publishers, 1997.
27. Malina RM, Peña Reyes ME, Eisenmann JC, Horta L, Rodrigues J, Miller R. Height, mass and skeletal maturity of elite Portuguese soccer players aged 11-16 years. J Sport Sci 2000;18:685-93.
28. Damsgaard R, Bencke J, Matthiesen G, Petersen JH, Müller J. Body proportions, body composition and pubertal development of children in competitive sports. Scand J Med Sci Sports 2001;11:54-60.
29. Rodrigues AN, Perez AJ, Carletti L, Bissoli NS, Abreu GR. Consumo máximo de oxigênio, adolescentes, aptidão aeróbia, teste cardiopulmonar. J Pediatr (Rio J) 2006;82(6):426-30.

Endereço para correspondência
Leslie Andrews Portes
Estrada de Itapecerica, 5859, Jardim IAE.
UNASP – Centro Universitário Adventista
de São Paulo. Curso de Educação Física
CEP: 05858-001 - São Paulo, SP. Brasil
E-mail: leslie.portes@unasp.edu.br.