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Soccer Players: Comparisons amongst Elite, Sub-elite and Non-elite Players with Non-players

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ABSTRACT

The aim of the present study was to compare the anthropometry and somatotype of pre-adolescent soccer players of a wide range of levels and ages, and boys of the general population, in order to define the most relevant anthropometric characteristics related to success and promotion to youth soccer elite levels. To this end, 528 youngsters (11.9±0.3 years) divided in four different age groups (Under-11, Under-12, Under-13 and Under-14) and four different training levels (elite, sub-elite and non-elite soccer players, and the general population) were compared. Height, body mass, skinfolds, and limb diameters and circumferences were measured. Moreover, body composition and somatotype were calculated. To determine the differences between the training groups in each age group, the effect size (Cohen's d) was calculated. Elite players were significantly taller than the rest of the players across all ages (d=0.30–1.18). In the Under-11 group, elite players were lighter than sub-elite players and the general population (d=0.30–0.54) but, as age increased, elite players became heavier than players in the rest of the groups (d=0.28–0.87). Also, our findings indicate that elite players had the lowest BMI (d=0.21–0.84), and the smallest limb diameters (d=0.24–1.19) and circumferences (d=0.22–0.96) across all ages. In addition, elite and sub-elite players had significantly lower values of skinfolds (d=0.21–2.18) and, the lowest fat (d=0.24–1.35) and the highest muscle (d=0.40–1.47) percentages. Finally, while mesomorphy was the major component in elite and sub-elite players (d=0.27–0.89), non-elite players and the general population presented higher levels of endomorphy (d=0.72–2.21). The present study supports the idea that young soccer players are bigger and leaner than their age counterparts who never engaged in regular sporting activity. Moreover, high fat percentage appeared to be a negative factor related to the selection of players..

Key words: *youth soccer, age, anthropometry, somatotype*

Introduction

Regardless of the sport discipline, it is important that athletes have favorable anthropometric and physiological characteristics to achieve optimal performance. In the case of youth soccer, success has been reported to be associated with specific anthropometrical (i.e. height, body mass, body composition), physiological (i.e. VO_{2max}) and performance (i.e. jump, endurance, agility) characteristics[1–6]. Therefore, these characteristics may serve as guidance in the talent identification and selection processes in order to discover those players who could potentially become professionals.

In this regard, the study of players' anthropometrical and morphological characteristics contributes significantly to understanding the overall concept of performance. As such, it has been observed that youth soccer players classified in different playing levels differ in body size and body composition; in this sense, elite players tend to be taller, bigger and have a higher level of fitness and greater technical ability than sub-elite and non-elite soccer players[3,7–9]. Likewise, when comparing young non-professional soccer players and the general population, it has been observed that soccer players were taller and bigger and had larger limb diameters[10,11].

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Characterizing the profile of successful players could give coaches and scouts better knowledge of this particular group of athletes and may serve as a template for comparison with other young players. However, comparing results in young soccer players is not an easy task due the rapid changes in anthropometrical and physiological characteristics that occur during this period of growth[12]. For instance, in a study performed across three age categories (under 14, 15 and 16 years of age) in academy-based elite adolescent soccer players, Le Gall et al. (2010) observed significant differences in several of the anthropometric and physical performance variables. They concluded that measures were dependant on age categories[8]. As a consequence, a detailed comparison of players within each age range becomes necessary. Nowadays a rising number of very young boys specialize early in soccer and are being identified as being talented. However, most of the studies available to date have been based on older participants, specifically adolescent and post-pubertal players [8,9,12], i.e. research about pre-adolescent soccer players is scarce. Knowledge of the differences amongst players of various levels and across different age ranges could provide coaches and technical staff involved in young soccer a model as guidance for the identification and selection of players in soccer clubs. Hence, the objective of the present study was to compare the anthropometry and the somatotype of pre-adolescent soccer players of a wide range of levels and ages, and boys of the general population. In particular, we aimed to characterize non-elite, sub-elite and elite players to define the most relevant anthropometric characteristics related to success and promotion to the elite level in youth soccer.

Materials and Methods

Sample

The sample included a total of 528 male youngsters belonging to four different age groups: Under-11 (U11, 10.40±0.2 years), Under-12 (U12, 11.45±0.3 years), Under-13 (U13, 12.31±0.30 years) and Under-14 (U14, 13.34±0.27 years) and four different playing levels (elite soccer players, sub-elite soccer players, non-elite soccer players, and the general population). Specifically, players of the elite group were part of the youth categories of a professional soccer club (the Spanish »La Liga«) and played in the academy team. Concerning the sub-elite group, players were also part of the talent identification system within the same professional soccer club. However, although players were identified by this club, instead of entering the academy, they were integrated in the regional clubs. Similarly, players in the non-elite group belonged to two regional level teams, but they had not been identified, nor selected. Finally, the youngsters of the general population belonged to 4 different schools. To participate in the latter group, the exclusion criteria included previous and current participation in organized sport. All the participants lived in the same geographical area (same county). Goalkeepers were excluded from the analysis and, as a result, only outfield players were analyzed. The number of participants analyzed in each age group and playing level is shown in Table 1.

Written informed consent was received from all players and parents or tutors after verbal and written explanation of the experimental design at the beginning of the study. The Ethics committee of University of the Basque Country for Research on Human Subjects approved this study. The measurements were performed according to the ethical standards of the Helsinki Declaration.

TABLE 1
NUMBER OF PARTICIPANTS WITHIN TRAINING GROUP AND AGE GROUP

	U11	U12	U13	U14	Total
General population	60	61	15	17	153
Non-elite players	13	27	27	25	92
Sub-elite players	44	42	30	22	138
Elite players	25	53	37	30	145
Total	142	183	109	94	528

Anthropometry

All anthropometric measurements were taken by two experienced observers following the guidelines outlined by the ISAK (International Society for the Advancement of Kinanthropometry)[13]. The same equipment and methodological procedures were adopted by the anthropometrists for all the measurements: players only wore shorts and testing took place at the same time of the day and under the same external conditions.

In order to evaluate the method of direct anthropometry, the intra-evaluator and the inter-evaluator Inter-Class Correlation Coefficient (ICC) and Technical Error of Measurement (TEM) were calculated. In order to perform the intra-evaluator calculation, the results of the measurements of 20 volunteers were considered at the first and second evaluation by each anthropometrist (TEM%=0.34–0.99; ICC=0.99–0.98). Similarly, to perform the inter-evaluator calculation, the measurements to be considered were performed by the two anthropometrists with the same group of volunteers. To this end, 16 randomly selected young soccer players were measured (TEM%=0.39; ICC=0.94).

Height was measured with a portable stadiometer (Añó Sayol, Barcelona, Spain) to the nearest 0.1 cm. Body mass was measured with a portable balance (Seca, Bonn, Germany) to the nearest 0.1 kg. The body mass index (BMI) was calculated from height and body mass (kg/m^2).

Skinfold thickness from the triceps, subscapular, abdominal, suprailiac, thigh and calf were measured with the Harpenden skinfold caliper (Baty, West Sussex, UK) and summed, as a surrogate of total adiposity (total-skinfolds). Also, the sum of trunk skinfolds (trunk-skinfolds= sum of subscapular, abdominal and suprailiac skinfolds) and the sum of extremities skinfolds (limb-skinfolds= sum of triceps, thigh and calf skinfolds) were calculated. The circumferences of the upper arm (relaxed and flexed), thigh and lower leg (to the nearest 0.1 cm) were measured using a tape measure (Lufkin, Germany). Four limb diameters (cm) were obtained using a caliper (Holtain, England): biepicondylar of the humerus (elbow), bystyloid of the wrist (wrist), biepycondilar of the femur (knee) and bimaleolar of the ankle (ankle).

Body composition and somatotype

The fat, bone and muscle components of the body, as percentages, were calculated.

Faulkner´s formula[14] was used to estimate the fat percentage, where this was defined as:

Fat percentage (%)=sum of skinfolds (tricipital+subes capular+suprailiac+abdominal) *0.153+5.783.

Bone weight was calculated using Rocha´s equation[15] and defined as:

Bone weight (kg)=3.02*(height^{2}*bystyloid diameter*biepicondylar diameter of femur*400)$^{0.712}$.

Other definitions included:

Bone percentage (%)=bone weight*100*body weight^{-1}.

Residual weight (kg)=total weight*24.1*100^{-1}.

Muscle weight (kg) was estimated using Matiegka´s formula[16] and defined as:

Muscle weight (kg)=total weight–(fat weight+bone weight+residual weight).

Muscle percentage (%)=muscle weight*100*body weight^{-1}.

Measurement results were used to calculate the somatotype. The somatotypes were classified as endomorphic, mesomorphic and ectomorphic according to Heath-Carter's modified somatotype method[17].

Statistical analysis

Mean and standard deviations were used to describe the groups. To determine the differences between the training groups, the magnitude of the differences or effect size (ES), known as Cohen's d, were calculated (Cohen, 1998) and interpreted as small (>0.2 and <0.5), moderate (≥0.5 and <0.8) and large (≥0.8)[18]. Statistical analyses of data were performed using the Statistical Package for the Social Sciences 21.0 software package (SPSS, Chicago, IL, USA).

Results

Mean measures related to body size (height, body mass and BMI) are shown by age group in Table 2. Regarding height, elite players were significantly taller than the rest of the participants across all the age groups (d=0.30–1.18) and differences were larger in the U13 (d=0.56–1.18) and

TABLE 2
DIFFERENCES IN HEIGHT, BODY MASS, AND BODY MASS INDEX BETWEEN THE DIFFERENT TRAINING GROUPS AND ACROSS THE DIFFERENT AGE GROUPS

Age group	Groups	Height (cm)	ES	Body mass (kg)	ES	BMI (kg/m^2)	ES
U11	GP	145.21±6.36	**E	41.39±8.38	*NE,E;**SE	19.57±3.29	*NE;**SE,E
	NE	144.54±6.31	**E	39.66±7.90	*SE	18.90±3.07	**SE,E
	SE	144.39±6.01	**E	36.76±4.34	**E	17.60±1.54	
	E	148.51±5.40		39.30±4.90		17.77±1.43	
U12	GP	149.40±6.59	**E	43034±7.42	**SE	19.32±2.31	*NE;**SE,E
	NE	150.68±8.11	*E	42.62±9.38	*SE	18.55±2.41	*SE,E
	SE	149.57±619	**E	39.78±5.89	*E	17.73±2.03	
	E	152.88±6.45		42.19±6.21		17.97±1.49	
U13	GP	158.88±8.42	**NE,E	51.91±12.62	*NE,SE	20.34±3.28	**SE,E
	NE	156.61±6.46	**SE;***E	49.32±7.40	*SE,E	20.57±2.39	**E;***SE
	SE	158.67±7.73	**E	47.67±6.73	*E	18.85±1.63	***E
	E	163.04±7.70		50.92±7.95		19.04±1.52	
U14	GP	168.08±8.93	**E	55.88±10.08	*NE,E	20.35±2.13	*NE,SE
	NE	163.92±7.21	*SE;***E	52.28±6.70	*SE;***E	19.42±1.81	**E
	SE	166.27±7.29	**E	54.56±6.99	**E	19.69±1.63	*E
	E	170.51±5.20		58.43±7.31		20.05±1.79	

Values are presented as mean with standard deviation. GP – general population, NE – non-elite players, SE – sub-elite players, E – elite players, ES – effect size, BMI – body mass index. The magnitude of the differences between the training groups is indicated as: * small effect size (d≤0.2–0.5), ** medium effect size (d=0.5–0.8), *** large effect size (d≥0.8).

the U14 (d=0.74–1.04) groups. In this regard, large size effects were identified between elite players and non-elite players in the U13 (d=1.18) and the U14 (d=1.04) groups, as well as medium size effects between the elite players, sub-elite players and the general population (d=0.55–0.74). Regarding weight, in the U11 age group, elite players were significantly heavier than sub-elite players (d=0.54) and lighter than those in the general population (d=0.30). Nevertheless, as age increased, elite players became heavier than the rest (d=0.87–0.54). Also, results indicate that elite players had the lowest BMI among all the age groups (d=0.28–0.84) except for the U14 age group. Indeed, BMI increased in the elite group to the extent that the values became similar among the elite players and the general population (20.05±1.79 and 20.35±2.13, respectively).

Results in Table 3 showed that elite players' limb diameters were significantly smaller than those of the rest of the groups (d=0.28–1.62). Also, Table 4 reveals that relaxed and flexed arm circumferences were significantly smaller in the elite players across all the age groups (d=0.26–0.66 and d=0.70–0.92, respectively). Likewise, the elite players had smaller thigh (d=0.24–0.0.80) and leg (d=0.28–0.96) circumferences.

In relation to adiposity, elite and sub-elite players had overall significantly lower values of skinfold thicknesses at the 6 measured sites and, consequently, they had the smallest total-skinfolds, trunk-skinfolds, and limb-skinfolds (Table 5). Nevertheless, while in the U11 age group the total-skinfolds and limb-skinfolds were similar in both the elite and the sub-elite players, as age increased, differences between the groups became larger (d=0.48–1.32).

Regarding body composition (Table 6), elite players had the lowest fat and the highest muscle percentages among all the age groups (d=0.24–1.35 and d=0.40–1.47, respectively). With respect to somatotype (Table 7), all the groups revealed a predominance of mesomorphy. In fact, as age increased, mesomorphy was the main somatotype among all the age groups. However, in comparison with other groups, elite and sub-elite players were more ectomorphic (d=0.21–1.30). In contrast, higher values of the endomorph component were noticed among all the age groups in non-elite level soccer players and in the general population (d=0.75–2.21 and d=0.21–1.48, respectively).

Discussion

Although in recent years more and more children play soccer and selection processes are beginning to take place at earlier ages, the study populations in the literature related to youth soccer players are very often drawn from adolescent and post-pubertal elite soccer players and, consequently, information about younger players is scarce. Therefore, an interesting aspect of the current study is that measurements were taken in a large group of preadolescent youngsters of different age groups (U11, U12, U13 and U14) and different training levels (elite, non-elite, sub-elite and the general population).

TABLE 3
DIFFERENCES IN LIMB DIAMETERS BETWEEN THE DIFFERENT TRAINING GROUPS AND ACROSS THE DIFFERENT AGE GROUP

Age group	Groups	Elbow (cm)	ES	Wrist (cm)	ES	Knee (cm)	ES	Ankle (cm)	ES
U11	GP	5.85±0.41		4.81±0.46	*NE,SE,E	9.00±0.58	*NE;**SE;***E	6.48±0.38	*NE;***E
	NE	5.90±0.32		4.68±0.28		8.74±0.86	*E	6.60±0.37	*SE;***E
	SE	5.80±0.39		4.64±0.36		8.70±0.39	*E	6.45±0.56	**E
	E	5.63±0.29		4.52±0.27		7.65±0.38		5.20±0.34	
U12	GP	5.96±0.37	*E	4.87±0.33	*NE,SE	9.07±0.43	*SE;**E	6.58±0.38	**NE
	NE	6±0.50	*E	4.78±0.38	*E	9.03±0.58	*SE;**E	6.72±0.70	*SE
	SE	6±0.40	*E	4.79±0.29	*E	8.85±0.69	**E	6.61±0.30	
	E	5.81±0.39		4.67±0.28		8.51±0.64		5.97±0.65	
U13	GP	6.38±0.46	*E	5.07±0.37	*E	9.38±0.45	*SE;**E	6.80±0.33	*NE,E
	NE	6.33±0.38	**E	5.04±0.48	*E	9.33±0.78	**E	6.89±0.38	
	SE	6.32±0.36	*E	5.06±0.39	*E	9.27±0.49	***E	6.87±0.41	
	E	6.12±0.41		4.92±0.28		9.31±0.45		6.67±0.68	
U14	GP	6.70±0.50	*E	5.63±0.47	**SE,E;***NE	9.64±0.56	*NE,SE,E	7.04±0.41	
	NE	6.51±0.27	**E	5.27±0.40	*SE	9.48±0.46	**E	6.99±0.41	*E
	SE	6.66±0.27	**E	5.38±0.24	*E	9.47±0.69	**E	7.04±0.38	
	E	6.53±0.37		5.17±0.34		9.64±0.40		6.91±0.36	

Values are presented as mean with standard deviation. GP – general population, NE – non-elite players, SE – sub-elite players, E – elite players, ES – effect size. The magnitude of the differences between the training groups is indicated as: * small effect size (d≤0.2–0.5), ** medium effect size (d=0.5–0.8), *** large effect size (d≥0.8).

TABLE 4
DIFFERENCES IN CIRCUMFERENCES BETWEEN THE DIFFERENT TRAINING GROUPS AND ACROSS THE DIFFERENT AGE GROUPS

Age group	Groups	Arm relaxed (cm)	ES	Arm flexed (cm)	ES	Thigh (cm)	ES	Leg (cm)	ES
U11	GP	23.31±3.15	*E;**SE	24.23±2.89	*E;**SE	44.98±5.49	**SE,E	31.76±2.97	*SE,E
	NE	23.89±3.69	*E;***SE	24.04±2.96	**SE	45.54±4.89	**SE,E	31.54±3.19	*SE,E
	SE	21.42±1.87	**E	22.72±1.58	**E	41.92±3.98		30.55±2.39	
	E	21.78±1.79		22.90±1.85		41.26±3.48		28.71±2.02	
U12	GP	23.51±2.56	*E;**SE	24.48±2.31	**SE	45.82±3.86	**SE;***E	32.55±2.54	*NE;**SE,E
	NE	2302±2.96	*SE	24.00±2.83	*SE	45.02±4.92	*SE,E	31.90±3.28	*SE,E
	SE	21.87±2.35	**E	23.26±2.11	**E	43.46±3.67		30.84±2.24	
	E	22.56±1.71		23.69±1.66		42.56±3.03		30.44±3.00	
U13	GP	25.30±3.06	*E;**SE	26.32±2.79	*E;**SE	48.41±5.63	**SE,E	34.43±3.62	*NE,SE,E
	NE	25.23±2.92	*E;**SE	25.84±2.45	*SE	48.03±6.17	*SE;**E	33.61±4.24	
	SE	23.59±1.86	*E	24.96±1.67	*E	45.85±3.45		33.20±1.89	
	E	22.94±1.75		24.35±1.78		43.15±2.68		31.11±2.25	
U14	GP	25.83±2.30	**NE,SE	27.18±2.42	*SE,E;**NE	49.28±4.39	*E	35.95±2.93	**NE,SE;***E
	NE	24.33±1.74	*SE;***E	25.62±1.63	*SE;***E	48.87±3.86		33.73±4.56	
	SE	24.76±1.68	**E	26.37±1.82	***E	49.08±358	*E	34.36±2.29	
	E	24.33±1.71		25.79±1.81		45.33±3.13		33.10±2.65	

Values are presented as mean with standard deviation. GP – general population, NE – non-elite players, SE – sub-elite players, E – elite players, ES – effect size. Magnitude of the differences between the training groups * small effect size (d<0.2), ** medium effect size (d=0.2-0.5), *** large effect size (d>0.5).

TABLE 5
SKINFOLD THICKNESS DIFFERENCES BETWEEN THE DIFFERENT TRAINING GROUPS AND ACROSS THE DIFFERENT AGE GROUPS

Age group	Groups	Total skinfolds (mm)	ES	Trunk skinfolds (mm)	ES	Limb skinfolds (mm)	ES
U11	GP	91.39±47.24	***SE,E	37.67±25.90	***SE,E	53.78±22.66	**SE; ***E
	NE	83.59±43.66	**SE,E	33.60±17.14	**SE,E	49.99±21.84	**SE,E
	SE	60.60±24.75		20.58±11.94		39.98±13.99	*E
	E	57.75±21.49		21.43±10.94		36.32±11.66	
U12	GP	79.72±30.65	**SE; ***E	32.09±17.28	**SE; ***E	47.64±15.13	***SE,E
	NE	77.67±32.87	**SE; ***E	29.96±17.14	**SE, ***E	47.70±16.55	**SE; ***E
	SE	59.21±22.67		22.43±12.16	*E	36.78±11.36	**E
	E	50.04±13.97		18.48±6.39		32.56±8.80	
U13	GP	84.84±41.40	*NE; ***SE,E	34.50±22.49	*NE,SE; ***E	50.34±20.09	*NE; ***SE,E
	NE	94.62±34.62	***SE,E	41.59±26.90	***SE,E	58.51±20.61	***SE,E
	SE	56.62±21.03	***E	21.65±9.56		34.97±12.32	*E
	E	50.60±14.28		20.67±7.86		29.93±7.67	
U14	GP	69.44±22.12	**SE; ***E	28.96±12.41	**SE,E	40.48±11.68	**SE; ***E
	NE	74.14±27.18	***SE,E	29.19±12.91	**SE,E	44.95±16.26	***SE,E
	SE	56.58±11.96	***E	22.69±6.77		33.90±6.51	***E
	E	46.65±12.00		21.79±5.82		24.86±6.55	

Values are presented as mean with standard deviation. GP – general population, NE – non-elite players, SE – sub-elite players, E – elite players, ES – effect size. The magnitude of the differences between the training groups is represented as: * small effect size (d≤0.2–0.5), ** medium effect size (d=0.5–0.8), *** large effect size (d≥0.8).

TABLE 6
BODY COMPOSITION DIFFERENCES BETWEEN THE DIFFERENT TRAINING GROUPS AND ACROSS THE DIFFERENT AGE GROUPS

Age group	Groups	Fat %	ES	Muscle %	ES	Bone %	ES
U11	GP	13.84±4.79	***SE,E	43.72±3.33	**SE; ***E	18.74±2.44	*SE
	NE	13.09±4.55	**SE,E	44.11±2.59	**SE; ***E	18.70±2.69	*SE
	SE	10.64±2.29		45.64±2.00	*E	19.62±1.83	*E
	E	10.50±2.03		46.50±1.88		18.90±1.45	
U12	GP	12.72±3.14	**SE; ***E	44.38±2.20	*SE; ***E	18.80±1.83	*NE; **SE; ***E
	NE	12.38±3.40	**SE; ***E	44.36±2.26	*SE; ***E	19.16±1.75	*SE; **E
	SE	10.83±2.39		45.28±2.14	*E	19.78±2.00	
	E	9.85±1.27		46.09±1.07		19.99±0.96	
U13	GP	13.29±4.21	***SE,E	44.35±2.90	**SE,E	18.26±1.98	**SE; ***E
	NE	13.98±3.66	***SE,E	43.88±2.80	***SE,E	18.04±2.05	**SE; ***E
	SE	10.59±1.88	*E	46.00±1.65		19.31±1.77	*E
	E	10.17±1.53		46.09±1.41		19.64±1.27	
U14	GP	11.81±2.34	**SE; ***E	44.65±2.20	***SE,E	19.44±2.04	*E
	NE	12.05±2.62	**SE; ***E	44.59±2.00	***SE,E	19.26±1.66	*E
	SE	10.58±1.20	*E	46.43±1.30	*E	19.09±1.41	*E
	E	10.24±1.17		46.88±0.90		18.78±1.34	

Values are presented as mean with standard deviation. GP – general population, NE – non-elite players, SE – sub-elite players, E – elite players, ES – effect size. The magnitude of the differences between the training groups is indicated as: * small effect size (d≤0.2–0.5), ** medium effect size (d=0.5–0.8), *** large effect size (d≥0.8).

TABLE 7
SOMATOTYPE DIFFERENCES BETWEEN THE DIFFERENT TRAINING GROUPS AND ACROSS THE DIFFERENT AGE GROUPS

Age group	Groups	Endomorphy	ES	Mesomorphy	ES	Ectomorphy	ES
U11	GP	4.15±2.16	*NE; ***E,SE	4.87±1.26	*SE; ***E	2.46±1.59	**SE,E
	NE	3.77±1.27	***SE,E	4.97±1.27	**SE; ***E	2.72±1.55	*SE; **E
	SE	2.71±0.94	*E	4.34±0.94	*E	3.27±1.02	*E
	E	2.34±0.95		3.96±1.00		3.47±0.82	
U12	GP	3.54±1.39	**SE; ***E	4.73±0.89	*NE; **SE,E	2.72±1.12	*NE; **SE; ***E
	NE	3.33±0.82	**SE,E	4.34±0.82	*SE,E	3.21±0.98	*SE; **E
	SE	2.66±0.96	*E	4.08±0.96		3.60±1.20	
	E	1.95±0.59		4.13±0.73		3.66±0.70	
U13	GP	3.61±1.58	*NE; ***SE,E	4.58±1.04	*NE,SE,E	2.88±1.36	*NE; **SE,E
	NE	4.07±1.18	***SE,E	4.88±1.18	**SE,E	2.43±1.14	**SE,E
	SE	2.35±0.81	**E	4.13±0.81		3.54±0.96	*E
	E	1.99±0.61		4.15±0.83		3.71±0.71	
U14	GP	2.87±1.14	***E	4.65±0.85	**SE;***NE,E	3.16±1.02	*NE,SE; **E
	NE	2.99±0.87	***E	3.87±0.87		3.59±1.09	
	SE	2.99±0.95	***E	3.97±0.95		3.58±0.91	
	E	1.92±0.53		3.86±0.92		3.66±0.90	

Values are presented as mean with standard deviation. GP – general population, NE – non-elite players, SE – sub-elite players, E – elite players, ES – effect size. The magnitude of the differences between the training groups is indicated as: * small effect size (d<0.2), ** medium effect size (d=0.2–0.5), *** large effect size (d>0.8).

In line with the notion that young male athletes tend to be taller than average[19], the elite players in the present study were found to be taller than the rest of the training groups across all ages. However, in contrast to the standard reports that soccer players tend to be heavier than their age-matched peers[8,10], we found that elite players tended to be lighter than the rest of the groups in the youngest ages and that they became significantly heavier as age increased. A similar trend was observed for the BMI; elite players' BMI values were lower in the youngest groups and became higher in the U14 age group. Moreover, elite players' BMI values were similar to those of the general population (20.05±1.79 and 20.35±2.13, respectively). The BMI has been used as an index of adiposity in epidemiological studies; nevertheless, as recognized for adult athletes, the BMI may not be an appropriate tool to measure adiposity in young athletes. In fact, since the weight included in the BMI formula does not distinguish between fat and muscle, it is possible that the elite group had lower BMI values at the younger ages due to their lower adiposity and, in contrast, had larger values in the eldest group due to their larger muscularity.

Previous studies have reported longer limb diameters and circumferences in elite youth soccer players[20]. In contrast, in our study, elite players had the smallest diameters and circumferences amongst all the age groups. These results may be partially accounted for by a lower amount of subcutaneous fat. Indeed, it is well known that the same weight of fat takes up more space (or volume) than muscle[21]. As such, if we considered that elite players had lower levels of total-skinfolds and fat percentage than the rest of the training groups, it is reasonable to think that the volume of their limbs would be smaller and, thus, their diameters and circumferences would also be shorter.

In line with the aforementioned results, when skinfold thicknesses were closely analyzed, parameters indicated that elite players had significantly lower values of adiposity than non-elite players and the general population in limb-skinfolds across all the age groups. Furthermore, elite players and sub-elite players showed the smallest total-skinfolds and fat percentage values for all ages. This was to be expected as previous studies have shown that the percentage of fat of soccer players is around 11%, which is lower than that of the general population[10,22]. However, it is interesting to note that while in the youngest age groups, skinfold thicknesses were similar in the elite and the sub-elite groups, differences became larger as age increased. Thus, elite players exhibited a significantly lower fat percentage than sub-elite players. There are two non-exclusive explanations for this finding. On the one hand, it is well know that fat has a negative influence on performance[3,10]. Therefore, it is possible that those players who displayed better performance, and coincidentally have lower fat percentages, were selected to join higher level soccer teams[23]. On the other hand, training at an elite level usually involves longer and more intense training sessions which may lead to a reduction of fat levels. Altogether, these results suggest that having lower values of fat seems to be important to play at elite level, at least at the youngest ages.

Another issue that is worth mentioning is the absence of differences between non-elite players and the general population in regard to skinfold thicknesses. Indeed, the amount of body fat and its distribution appeared to be quite similar in both groups. These findings are surprising since the non-elite youngsters played soccer regularly. Nowadays, obesity and its related disorders in puberty and adolescence are an important public health issue and sport has been considered to be a promising setting for obesity prevention. Thus, taking into account the results of the present study, it seems that regular participation in a sport *per se* cannot guarantee reduced fat levels in children. Similarly, a previous study has demonstrated that even in highly trained athletes, adiposity affects health and performance[24]. Moreover, a recent study performed with 83 elite male athletes reported that, even in those individuals participating in moderate-to-vigorous physical activity, the risk of having increased adiposity increased simply by more sedentary behaviour (sitting, watching TV, etc.)[25]. Considering these results, when policies to prevent obesity are promoted for the young population, additional strategies other than physical activity and sport should also be included, such as interventions to encourage children to play actively or nutritional counselling.

Regarding somatotype, in agreement with what has been reported in the literature, all the groups revealed predominance for mesomorphy[26,27]. Nevertheless, while a trend for ectomorphy was found in the elite players and the sub-elite players, non-elite players and the general population presented higher levels of endomorphy. On the one hand, these results confirm that high-level soccer players have a tendency towards lower endomorphy than similar boys from the general population. On the other hand, as endomorphy is a correlate of fat, results are consistent with idea that lower fat percentages are associated with better physical performance and therefore, the young players selected to play in the elite teams tend to be leaner.

Collectively, the present study provides comprehensive information about the profile of youth soccer players according to their playing level and age group. This information may be a valuable tool for coaches and technical staff in the talent identification and selection process of young players. However, coaches also should bear in mind that although the mentioned anthropometrical characteristics appeared to be important for young soccer players to play at the elite level, the possibility exists that the morphologic features of players will change in the future and, therefore, the characteristics required for promotion to elite levels in adulthood will not necessarily be preserved.

Conclusion

Overall, the trends observed in the present study support the idea that young soccer players are bigger and leaner than their age counterparts who never engaged in regular sporting activity. Also, coaches should bear in mind that an excessive amount of fat is one of the most important negative factors related to selection, presumably due to the negative influence of fat adiposity on performance. Finally, taking into account the results concerning fat adiposity indicators, it seems that regular participation in a sport *per se* cannot guarantee reduced fat levels. Therefore, future research using longitudinal studies are needed to provide more information about adequate quantity and quality of physical activity for children.

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ANTROPOMETRIJA I SOMATOTIPOVI PREADOLESCENTNIH NOGOMETAŠA: USPOREDBE IZMEĐU ELITNIH, POLUELITNIH I NEELITNIH IGRAČA S NEIGRAČIMA

SAŽETAK

Cilj ovog istraživanja bio je usporediti antropometriju i somatotipove predadolescentnih nogometaše iz širokog raspona razina i dobi, te dječaka u općoj populaciji, kako bi se definirale najrelevantnije antropometrijske karakteristike vezane za uspjeh i napredovanje mladih elitnih nogometaša. U tu svrhu, 528 mladih ispitanika (11,9 ± 0,3 godina) su podijeljena u četiri različite dobne skupine (ispod-11, U-12, U-13 i U-14), i četiri različite razine treniranosti (elitni, pod-elitni i ne-elitni nogometaši, i dječake iz opće populacije), a njima su izmjerene tjelesna težina, visina, razina naboranosti kože i promjeri i opsezi udova. Osim toga, izračunati su sastavi tijela i somatotipovi. Kako bi se utvrdile razlike između grupa treniranosti u svakoj dobnoj skupini je izračunata razina učinka (Cohenov d). Elitni igrači su bili znatno viši od ostatka igrača iz svih dobnih skupina (d = 0,30 do 1,18). U skupini U-11, elitni igrači su bili lakši od pod-elitnih igrača i ispitanika opće populacije (d = ,30–,54), ali, kako se dob povećava, elitni igrači su postali teži od igrača u ostalim skupinama (d = 0.28– 0,87).

Također, naši rezultati pokazuju da elitni igrači imaju najniži BMI (d = 0.21–0.84), a najmanji promjer ekstremiteta (d = 0,24 – 1,19) i opseg ekstremiteta (d = 0,22 do 0,96) u svim dobnim skupinama. Osim toga, elita i pod-elitni igrači imali su značajno niže vrijednosti naboranosti kože (d = 0,21 do 2,18), i najniži udio masti (d = 0,24 – 1,35) i najviši udio mišića (D = 0.40–1.47) u postocima. Konačno, dok je, mezomorfija je bila glavni sastojak kod elitnih i pod-elitnih igrača (d = 0,27 do 0,89), ne-elitnih igrača i ispitanika opće populacije predstavila je višu razinu endomorfije (d = 0,72 do 2,21). Ova studija podupire ideju da su mladi nogometaši su mišićaviji i veći od svojih kolega koji nikada nisu sudjelovali u redovitim sportskim aktivnostima. Štoviše, čini se da je visok postotak masnoće negativan faktor povezan sa izborom igrača.