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ORIGINAL ARTICLE

Physique and Body Composition in Soccer Players across Adolescence

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Abstract

***Purpose*: Although the contribution of physique and body composition in soccer performance was recognized, these parameters of physical fitness were not well-studied in adolescent players. Aim of this study was to investigate physique and body composition across adolescence.**

***Methods*: Male adolescents (*N*=297 aged 12.01-20.98 y), classified into nine one-year age-groups, child (control group, *N*=16 aged 7.34-11.97 y) and adult players (control group, *N*=29 aged 21.01-31.59 y), all members of competitive soccer clubs, performed a series of anthropometric measures (body mass, height, skinfolds, circumferences and girths), from which body mass index (BMI), percentage of body fat (BF%), fat mass (FM), fat free mass (FFM) and somatotype (Heath-Carter method) were calculated.**

***Results*: Age had a positive association with FM (*r*=0.2, *P*<0.001) and FFM (*r*=0.68, *P*<0.001), and a negative association with BF (*r*=-0.12, *P*=0.047). Somatotype components changed across adolescence as well; age was linked to endomorphy (*r*=-0.17, *P*=0.005), mesomorphy (*r*=0.14, *P*=0.019) and ectomorphy (*r*=-0.17, *P*=0.004). Compared with age-matched general population, participants exhibited equal body mass, higher stature, lower body mass index and lower BF.**

***Conclusions*: During adolescence, soccer players presented significant differences in terms of body composition and physique. Thus, these findings could be employed by coaches and fitness trainers engaged in soccer training in the context of physical fitness assessment and talent identification.**

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INTRODUCTION

Whereas the contribution of physique and body composition in soccer performance was recognized, these parameters of physical fitness were not well-studied in adolescent players. According to recent researches conducted in adults, body composition was related to parameters of soccer performance, it differed from general population and differences were shown between starters and substitutes as well as between playing positions. For instance, body mass and fat free mass (FFM) were related to the total distance covered in international players [1]. Adult male players had a lower percentage of body fat (BF) compared with the reference population (10% vs. 16.7% accordingly)[2]. BF discriminated female starter players from substitutes (21.8% vs. 24.3% respectively)[3]. In male soccer players, BF, fat mass (FM) and FFM differences according to position were recorded[4-6]. Players in the first Turkish league were less endomorphic, more mesomorphic and less ectomorphic than those in the second league (2.4-4.8-2.3 vs. 3-4.5-2.6) [5]. Players in the first Serbian league were taller and heavier than those in the third league[7].

There were also indications of the importance of body composition for soccer performance in younger age. Child and adolescent players, aged 9-14.9 y had a significantly lower BF than reference population[8]. Starters players, aged 10-14 y, were leaner than substitutes[9]. Variation of body composition according to playing position was reported in players with 14-21 years of age[10], and in players with 16-18 years of age[11], in which defenders were characterized with lower BF. Moreover, 14-17-year-old successful players were taller, heavier and leaner than their non-selected counterparts[12].

Several studies revealed an association between age and body composition across adolescence. Nevertheless, there was no consensus regarding the direction of this association. Both increase and decrease of BF across adolescence were reported in relevant studies. Under-19-year-old players had lower BF and higher FFM than U16 (14.3±2.3% vs. 16.6±2% and 47.1±4.1 vs. 40.8±1.8 kg respectively) [13], whereas in a study of French players, BF increased from 11.5 y (10.6±1%) till 18 y (13.6±1.2%), and FFM increased too (35.6±4 kg vs. 58.6±5.9 kg respectively) [14].

Consequently, further investigations into body composition fluctuation in adolescent soccer players seemed necessary. Aim of this study was to investigate the effect of age on selected body composition parameters (BF, FM and FFM) and somatotype across adolescence, as well as to compare adolescent age groups with child and adult control groups with respect to these traits. The null hypotheses that there was no difference between age groups and there was no association between age and these parameters were examined.

METHODS AND SUBJECTS

Participants and procedures:

A non-experimental, descriptive-correlational design was used in this investigation. Testing procedures were performed during competition season 2009-2010. The study was approved by the local Institutional Review Board. Oral informed consent was received from all participants or parents after verbal explanation of the experimental design. Adolescence was suggested to range between 10 and 22 years of age in boys, although it was a difficult period to be defined in terms of chronological age, because of variation in time of its onset and termination [15], and it was the period that consisted of a foundation stone for future athletic excellence. Male adolescent (*N*=290; aged 12.01-20.98 y), classified into nine one-year age-groups (group under thirteen U13, aged 12.01-13 y; U14, 13.01-14 y, U15, 14.01-15 y, U16, 15.01-16 y; U17, 16.01-17 y; U18, 17.01-18 y; U19, 18.01-19 y; U20, 19.01-20 y; U21, 20.01-21 y), child (control group, U12, *N*=16, aged 7.34-11.8 y) and adult players (control group, C, *N*=28; aged 21.01-31.59 y), all members of competitive soccer clubs, practising soccer training from 3.25 h weekly in children to 8.5 h in adults, volunteered for this study (Table 1). Participants were familiarized with the testing procedures used in this study through pre-investigation familiarization sessions. They visited our laboratory once, where anthropometric and body composition data were obtained.

***Protocols and equipment*:**

Despite the development of several laboratory assessment methods of body composition, e.g. underwater weighting, air displacement plethysmo-graphy, labelled water techniques, bioelectrical impedance and dual-energy X-ray absorptiometry, these methods seemed inappropriate for field and clinical use[16,17]. Contrarily, skinfold and circum-ference measures offered inexpensive and non-invasive means to be administered in large samples [18,19]. Skinfold measures were employed in our study to estimate the body composition. All measurements were realized by qualified and experienced tester.

Height and body mass were measured using a

Table 1: Anthropometric data of participants (mean values with standard deviation in brackets)

Age group	*N*	Age (y)	Body mass (kg)	Stature (m)	BMI ($kg·m^{-2}$)
U12	16	10 (1.62)	40.37 (9.81)	1.417 (.08)	19.98 (3.56)
U13	30	12.58 (.27)	48.46 (8.72)	1.564 (.091)	19.66 (2.09)
U14	38	13.52 (.26)	56.66 (7.92)	1.665 (.073)	20.38 (2.19)
U15	55	14.56 (.27)	61.17 (9.25)	1.7 (.079)	21.12 (2.49)
U16	53	15.47 (.28)	65.82 (8.86)	1.732 (.06)	21.92 (2.51)
U17	37	16.51 (.3)	70.78 (12.8)	1.758 (.064)	22.9 (4.12)
U18	36	17.43 (.28)	69.48 (10.32)	1.753 (.054)	22.55 (2.58)
U19	15	18.37 (.32)	70.58 (6.51)	1.76 (.066)	22.77 (1.62)
U20	18	19.56 (.31)	73.19 (6.15)	1.767 (.051)	23.43 (1.64)
U21	15	20.58 (.31)	75.21 (6.42)	1.779 (.072)	23.77 (1.57)
C	29	25.3 (3.07)	76.7 (6.75)	1.795 (.059)	23.77 (1.17)

BMI: Body Mass Index

stadiometer (SECA, Leicester, UK) and an electronic scale (HD-351, Tanita, Illinois, USA) respectively. Percentage of body fat was calculated from the sum of 10 skinfolds using a skinfold calliper (Harpenden, West Sussex, UK), based on the formula proposed by Parizkova[20]. The anthropometric Heath-Carter method of somatotyping was employed for the quantification of shape and composition of the human body, expressed in a three-number rating representing endomorphy (relative fatness), mesomorphy (relative musculo-skeletal robustness), and ectomorphy (relative linearity or slenderness)[21].

Data and statistical analysis:

Results were presented as mean±*SD* (standard deviation). Data sets were checked for normality using the Shapiro-Wilks normality test and visual inspection. Association between body composition measures (BF, FM and FFM) and age was examined by Pearson moment correlation coefficient (*r*). Differences between different age-groups were assessed using one-way analysis of variance. Correction for multiple comparisons was undertaken using the Bonferroni method. The significance level was set at alpha=0.05. Statistical analyses were performed using SPSS v.17.0 statistical software (SPSS Inc., Chicago, IL, USA). Reference data of general population consisted of a sample of 9797 humans, aged 0-18 y, from the 1st Paediatric Clinic of University of Athens[22], and were employed for percentiles. For certain age groups (U14-U18), percentage of body fat (BF%) was compared with general population[23].

RESULTS

Analysis of variance revealed differences between age groups with respect to FM ($F_{10,331}$=3.34, P<0.001) and FFM ($F_{10,331}$=60.24, P<0.001), while there was no difference with respect to BF ($F_{10,331}$=1.46, P=0.152). Age had a positive association with FM (r=0.2, P<0.001) and FFM (r=0.68, P<0.001), and a negative association with BF (r=0.12, P=0.047). Body composition values are shown in Table 2 and the effect of age in Fig. 1. Somatotype components changed across adolescence too. Age was linked to endomorphy (r=-.17, P=.005), mesomorphy (r=0.14, P=0.019) and ectomorphy (r=0.17, P=0.004). Endomorphy and ectomorphy decreased, while mesomorphy increased in order to attain the adult soccer somatotype (3-4.9-2.3) (Table 3).

Across adolescence, mean values of body mass of the various groups were between 50th and 75th percentile (P_{50}-P_{75}), close to the line of P_{50} till U17,

Table 2: Body composition of participants (mean values with standard deviation in brackets)

Age group	BF (%)	Fat mass (kg)	Fat free mass (kg)
U12	18.57 (6.73)	7.99 (5.25)^{U17}	32.38 (5.07)$^{U13\text{-}U21,C}$
U13	16.61 (5.22)	8.27 (3.5)^{U17,C}	40.19 (6.47)$^{U12,U14\text{-}U21,C}$
U14	15.8 (3.57)	9.09 (2.87)	47.58 (6.03)$^{U12,U13,U16\text{-}U21,C}$
U15	16.43 (4.18)	10.26 (3.74)	50.92 (6.67)$^{U12,U13,U16\text{-}U21,C}$
U16	16.5 (3.94)	11.08 (3.98)	54.74 (5.95)$^{U12\text{-}U15,U17\text{-}U21,C}$
U17	16.29 (4.32)	11.97 (5.57)^{U12,U13}	58.81 (7.92)$^{U12\text{-}U16,U21,C}$
U18	15.8 (3.51)	11.21 (4.13)	58.27 (6.94)$^{U12\text{-}U15,U21,C}$
U19	14.75 (3.01)	10.42 (2.43)	60.16 (5.84)$^{U12\text{-}U16}$
U20	15.24 (3.46)	11.31 (3.31)	61.89 (3.75)$^{U12\text{-}U16}$
U21	14.45 (2.07)	10.9 (2)	64.31 (5.37)$^{U12\text{-}U18}$
C	15.06 (2.96)	11.64 (2.95)^{U13}	65.07 (5.13)$^{U12\text{-}U18}$

Age groups presented as exponents next to standard deviation denoted significant difference according to Bonferroni multiple comparison test.

BF: Body Fat

while U18 was between P_{25} and P_{50}, close to the line of P_{50}. Correspondingly, stature followed a trend similar to body mass, mean values were between P_{50} and P_{75}, beginning closer to the line of P_{75} for U12 and ending closer to the line of P_{50} for U17, while U18 was between P_{25} and P_{50}, close to the line of P_{50}. BMI was between P_{50} and P_{75}, close to the line of P_{50} in U12, while it was between P_{25} and P_{50} for all other age groups[22]. BF levels followed trends similar to general population (U14-U18). U14, U15 and U18 were between P_{25} and P_{50}, while U16 and U17 were slightly over P_{50}[23].

DISCUSSION

Whether body composition parameters (BF, FM and FFM) were associated with age during development was examined. The extent to which somatotype was

Table 3: Somatotype of participants (mean values with standard deviation in brackets)

Age group	Endomorphy	Mesomorphy	Ectomorphy
U12	5.5 (3)	4.5 (1.4)	2.1 (1.5)
U13	4.1 (2.2)*	4.5 (.9)	2.9 (1.1)
U14	3.4 (1.3) ‡	4.3 (1.1)	3.3. (1.3)
U15	3.6 (1.3) ‡	4.2 (1.2)	3.1 (1.4)
U16	3.6 (1.4) ‡	4.4 (1.2)	2.8 (1.5)
U17	3.4 (1.6) ‡	4.5 (1.5)	2.8 (1.6)
U18	3.4 (1.3) ‡	4.5 (1.2)	2.6 (1.3)
U19	3 (.9) ‡	4.7 (.9)	2.6 (.9)
U20	3.2 (1) ‡	4.9 (.9)	2.3 (1)
U21	2.8 (1) ‡	5 (1.1)	2.4 (1.1)
C	3.0 (0.9) ‡	4.9 (0.9)	2.3 (0.6)

*P<.05, ‡P<.001 denoted differences from child control group (U12)

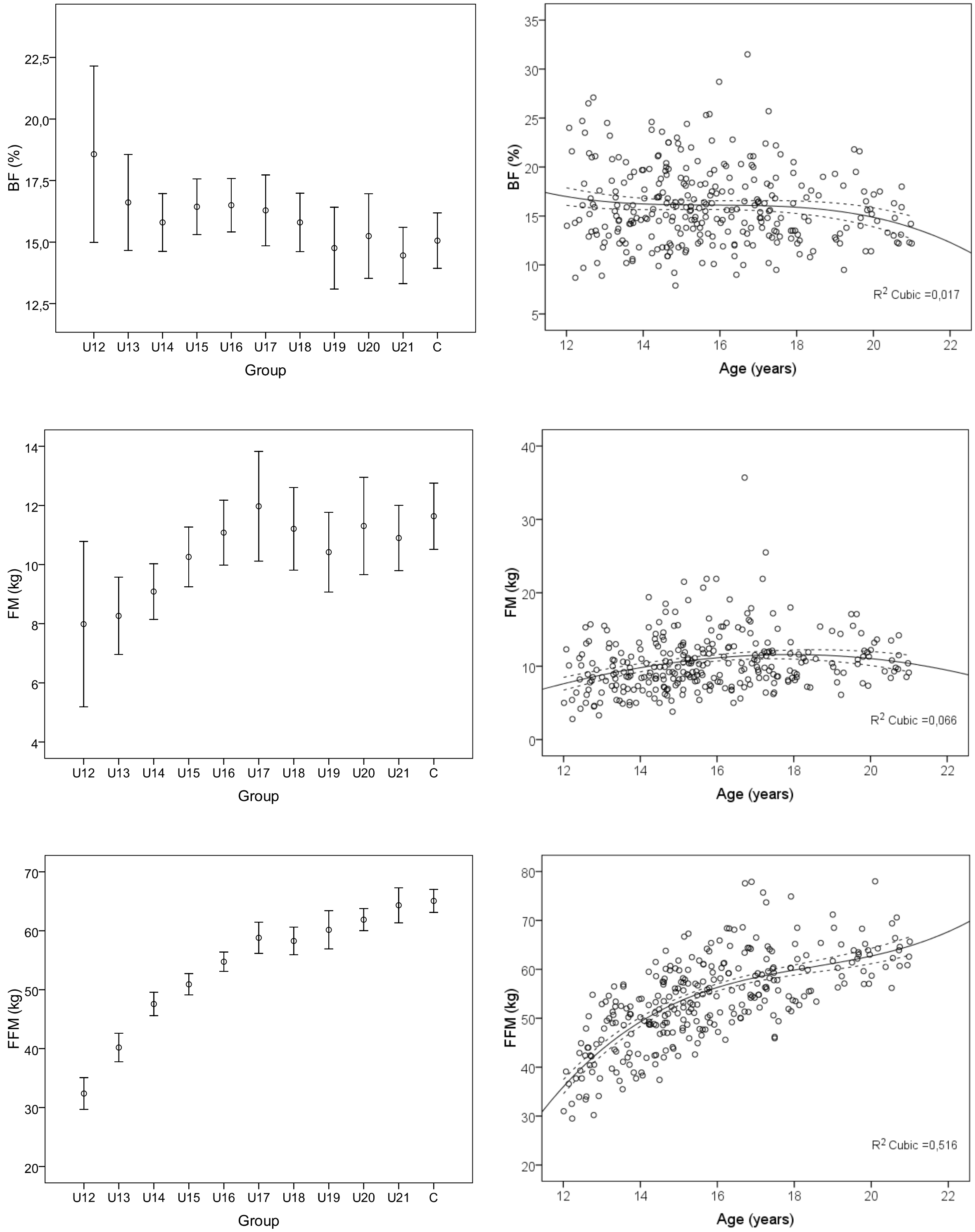

Fig. 1: Percentage of body fat (BF%), fat mass (FM) and fat free mass (FFM) for the adolescent and control groups, presented as means with 95% confidence intervals on the left and the association between corresponding body composition parameters and age with solid lines representing regression of the means and interval lines with 95% confidence intervals on the right.

dependant on age was also examined. In both cases data were compared with age-matched general population. The development of anthropometric characteristics and body composition in our sample followed a pattern similar to the general population, while there were differences in stature (taller) and in BMI (lower) with respect to the reference data. Values close to adulthood attained levels as suggested by the up-to-date literature, similar to a comparison of four European leagues (English, Spanish, Italian and German), in which stature was 1.80±0.06 m to 1.83±0.06 m, body mass was 74.3±5.4 to 77.5±6.4 kg, and BMI was 22.8±1.1 to 23.2±1.1 kg·m^{-2} [24].

Whereas there was no difference with respect to BF between age groups, BF was in a weak, but significant, inverse association with age. The main finding of this study was quantification of differences regarding body mass that were attributed mostly to FFM increase. Although there was a positive association between both FM and FFM, and age, the increases of these two components were disproportionate. Age corresponding to U17 was identified as a crucial turn point of adolescence, in which significant changes in FM and FFM were observed, the ratio of increase in FFM decreased and FM stopped to increase further.

Somatotype components changed across adolescence too. Age was linked to endomorphy, mesomorphy and ectomorphy. Particularly, endomorphy and ectomorphy decreased, while mesomorphy increased in order to attain the adult soccer somatotype (3-4.9-2.3), similar to those reporting from previous studies (2-5.5-2 in international players)[1]. No significant difference was observed between adolescent age groups with respect to endomorphy. Still, all the groups and the adult control group differed from child control group. Taken together, these results and the inverse relationship between age and endomorphy indicated a decrease of this somatotype component with development, i.e. the older the soccer player, the lower relative fatness, which came to terms with the corresponding trend of BF. Contrarily, mesomorphy was in positive association with age, i.e. the older the soccer player, the higher the relative musculo-skeletal robustness, which was in accordance with the development of FFM. Similarly, no significant difference among adolescent age groups was noticed regarding endomorphy. With regard to ectomorphy, no difference was observed between age groups, but there was a significant, weak, inverse association with age, i.e. the older the soccer player, the lower the relative linearity or slenderness. Recently, a study of 203 players, aged 14-19 y, showed somatotypes 2.5-4.2-3.4 in U15, 2.3-4.3-3.1 in U16, 2.6-4.4-2.6 in U17, 2.5-4.4-2.6 in U18 and 2.4-4.3-2.4 in U19, and indicated only a decrease in ectomorphy[25].

Body composition was in a strong interrelationship with physical activity (PA), i.e. higher PA levels resulted in lower BF and BMI, while people with lower BF and BMI achieved higher PA levels (inverse relationship between PA and BF or BMI). A main limitation of any study of current body composition scores is that the attribution of a physical characteristic either to talent or to previous training remains questionable. In the present study, participants were interviewed about their current training load (weekly time) and previous experience (years engaged in soccer). However, the possibility still remains that current values are due to systematic approach to training prior to induction into the team or due to non-sport physical activity levels.

This study was carried out on Greek soccer players. Consequently, its results could be generalized to similar populations of other countries, on the assumption that these countries were in similar or lower level than Greece (FIFA world ranking 10th on February 2011) [26]. It was presumed that in higher international levels, considering the contribution of body composition on soccer performance, players had better body compositions among the other parameters of physical fitness and thereafter, differences among age groups might be attenuated or even annihilated. Besides, the cross-sectional design of this investigation had the advantage of a well-controlled research environment, whereas longitudinal studies in spite of the difficulty of applying the same methods over long time could provide data about the same participants. Therefore, the combined use of cross-sectional and longitudinal study should be suggested for future research, in order to cover a long period and to be able to identify crucial “turn-points” across adolescence regarding changes in body composition.

Another limitation of this study was that only chronological age, without pubertal stage detection, was used to define the groups. A study of Di Luigi et al[27] showed that a group of 110 young Italian male soccer players ranging from 10 to 16 years of age, divided into seven different classes according to their birth-year, presented a high inter-individual variability of pubertal stage within the same class of chronological age. This can explain the variability of the physical parameters (height, FM, FFM, BF) during this particular age group (adolescence) and underlines the importance of the consideration of the pubertal age in addition to the chronological age in the talent identification and the exercise prescription. Even if chronological age was examined instead of biological, our findings could be used by coaches and fitness trainers for talent identification purpose, as well as for normative data of anthropometric, body composition characteristics and physique in adolescent soccer players.

CONCLUSION

In summary, this paper addressed the question of differences in body composition and physique across adolescence. Although there was no difference between adolescent age groups in BF, BF was weakly, but significantly, in inverse association with age, which was explained by the stronger effect of age on FFM than on FM. Since there was no consensus regarding the development of body composition, especially of BF, our results should be viewed with some caution until they get confirmed in other samples. Somatotype components changed across adolescence too; endomorphy and ectomorphy decreased, while mesomorphy increased.

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Conflict of interests: None

REFERENCES

1. Rienzi E, Drust B, Reilly T, et al. Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *J Sports Med Phys Fitness* 2000;40:162-9.
2. Bandyopadhyay A. Anthropometry and body composition in soccer and volleyball players in West Bengal, India *J Physiol Anthropol.* 2007;26:501-5.
3. Nikolaidis P. Physiological characteristics of elite Greek female soccer players. *Medicina dello Sport* 2010;63:343-51.
4. Carling C, Orhant E. Variation in body composition in professional soccer players: interseasonal and intraseasonal changes and the effects of exposure time and player position. *J Strength Cond Res* 2010;24:1332-9.
5. Hazir T. Physical characteristics and somatotype of soccer players according to playing level and position. *J Hum Kinetics* 2010;26:83-95.
6. Sutton L, Scott M, Wallace J, Reilly T. Body composition of English premier league soccer players: infuence of playing position, international status and ethnicity. *J Sports Sci* 2009;27:1019-26.
7. Ostojic SM. Elite and nonelite soccer players: preseasonal physical and physiological characteristics. *Res Sports Med* 2004;12:143-50.
8. Moreno LA, Leon JF, Seron R, et al. Body composition in young male football (soccer) players. *Nutr Res* 2004;24:235-42.
9. Gravina L, Gil SM, Ruiz F, et al. Anthropometric and physiological differences between first team and reserve soccer players aged 10-14 years at the beginning and end of the season. *J Strength Cond Res* 2008;22:1308-14.
10. Gil SM, Gil J, Ruiz F, et al. Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. *J Strength Cond Res* 2007;21:438-45.

11. Tahara Y, Moji K, Tsunawake N, et al. Physique, body composition and maximum oxygen consumption of selected soccer players of Kunimi High School, Nagasaki, Japan. *J Physiol Anthropol* 2006;25:291-7.
12. Gil S, Ruiz F, Irazusta A, et al. Selection of young soccer players in terms of anthropometric and physiological factors. *J Sports Med Phys Fitness* 2007;47:25-32.
13. Manna I, Khanna GL, Dhara PC. Effect of training on physiological and biochemical variables of soccer players of different age groups. *Asian J Sports Med* 2010;1:5-22.
14. Le Gall F, Beillot J, Rochcongar P. Evolution de la puissance maximale anaérobie au cours de la croissance chez le footballeur. *Sci Sports* 2002;17:177-88.
15. Malina RM, Bouchard C, Bar-Or O. *Growth, Maturation and Physical Activity*. Champaign: Human Kinetics 2004; Pp:3-20.
16. Luciano A, Livieri C, Di Pietro ME, et al. Definition of obesity in childhood: criteria and limits. *Minerva Pediatr* 2003;55: 453-60.
17. Rodriguez G, Moreno LA, Blay MG, et al. Body composition in adolescents: measurements and metabolic aspects. *Int J Obes* 2004;28:S54-S58.
18. Chou YC, Pei JS. Risk factors of adolescent obesity in Taiwan and its association with physical activity, blood pressure and waist circumference. *Asian J Sports Med* 2010;1:214-22.
19. Sandhu JS, Gupta G, Shenoy S. Prediction equation for calculating fat mass in young Indian adults. *Asian J Sports Med* 2010;1:201-8.
20. Parizkova J. Lean body mass and depot fat during autogenesis in humans. In: Parizkova J, Rogozkin V (eds). *Nutrition, Physical Fitness and Health: International Series on Sport Sciences.* Baltimore, MA: University Park Press. 1978; Pp: 22.
21. Heath BH, Carter JEL. A modified somatotype method. *Am J Physical Anthropol* 1967;27:57-74.
22. Chiotis D, Tsiftis G, Hatzisymeon M, et al. Height and weight of children of Hellenic origin aged 0-18 years (2000-2001): comparison with data collected during the period 1978-1979. *Ann Clin Pediatr Univ Atheniensis* 2003;50(2):136-155. (In Greek).
23. Moreno LA, Mesana MI, Gonzalez-Gross M, et al. Anthropometric body fat composition reference values in Spanish adolescents: the AVENA study. *Eur J Clin Nutr* 2006;60:191-6.
24. Bloomfield J, Polman R, Butterly R, O'Donoghue P. Analysis of age, stature, body mass, BMI and quality of elite soccer players from 4 European leagues. *J Sports Med Phys Fitness* 2005;45:58-67.
25. Gil SM, Gil J, Ruiz F, et al. Anthropometrical characteristics and somatotype of young soccer players and their comparison with the general population. *Biol Sport* 2010;27:17-24.
26. FIFA/Coca-Cola World Ranking. Available at: www.fifa.com/worldfootball/ranking/lastranking/gender=m/fullranking.html. Access date: Mar 2, 2011.
27. Di Luigi L, Baldari C, Gallotta MC, et al. Salivary steroids at rest and after a training load in young male athletes: relationship with chronological age and pubertal development. *Int J Sports Med* 2006;27:709-17.