



Official Research Journal of
the American Society of
Exercise Physiologists

ISSN 1097-9751

JEPonline

Percentage of Body Fat of Young Soccer Players: Comparison of Proposed Regression Frequencies between Goalkeepers and Soccer Camp Players

Thiago Santi-Maria¹, Rossana Gómez Campos^{1,2,3}, Cynthia Lee Andruske⁴, Diego Henrique Gamero¹ Cristian Luarte Rocha⁵, Miguel de Arruda¹, Ernesto Nayer Tumi-Figueroa⁶, Marco Cossio-Bolaños^{1,4,7,8}

¹Faculty of Physical Education, State University of Campinas, São Paulo, Brazil, ²Instituto de Actividad Física y Salud, Universidad Autonoma de Chile, Talca, Chile, ³Universidad Científica del Sur, Lima, Perú, ⁴Red de investigación en desarrollo biológico humano, Perú, ⁵Facultad de Ciencias de la Actividad Física, Universidad San Sebastian, Concepción, Chile, ⁶Departamento de Estadística e Informática, Universidad Nacional del Altiplano, Puno, Perú, ⁷Department of Physical Activity Sciences, Catholic University of Maule, Chile, ⁸University Sports Institute. National University of San Agustin, Arequipa, Perú

ABSTRACT

Santi-Maria T, Gómez Campos R, Andruske CL, Gamero DH, Luarte-Rocha C, Arruda M, Tumi-Figuero E, Cossio-Bolaños M. Percentage of Body Fat of Young Soccer Players: Comparison of Proposed Regression Frequencies between Goalkeepers and Soccer Camp Players. **JEPonline** 2015;18(6):70-80. The purpose of this study is twofold: (a) compare the percentage of fat between players in different positions; and (b) propose specific equations to compare goalkeepers and the other players in the soccer camp. Through convenience sampling, 163 soccer players were selected from the Brazilian Soccer League. Measurements were taken for weight, height, sitting height, and seven skinfolds. The percentage of body fat was estimated by dual-energy X-ray absorptiometry. Results indicated that the goalkeepers and other soccer camp players showed anthropometric and body composition differences. Six regression equations were generated to estimate the % body fat. The R² values varied between 0.71 and 0.94 and the SEE from 1.89 to 2.28%. These findings indicate that the goalkeepers and soccer camp players showed specific anthropometric and body composition

characteristics. Furthermore, the equations generated may be used to estimate percentage of body fat for both goalkeepers and soccer camp players.

Key Words: Regression equations, Dual-energy X-ray absorptiometry, Soccer, Youth

INTRODUCTION

The physical composition of the body (i.e., body fat, body mass, and mass free from fat) is relevant in the evaluation and preparation of soccer players (4). No doubt that is why various methods are used to estimate the body composition of athletes and non-athletes. For example, underwater weighing, air displacement plethysmography, labeled water techniques, and dual-energy X-ray absorptiometry (DXA) are relevant reference methods for assessing the body composition (23). However, these methods are not adequate for field studies (6), especially since they require substantial training to use, professional certification, significant investment costs (22), and adequate facilities and special care for the equipment to function.

An alternative is anthropometry, which is the science that defines physical measures of a person's size, form, and functional capacities. This method is considered applicable to everyday field situations. Moreover, the advantages of low cost and ease of administering encourage its use by multidisciplinary teams working in soccer clubs. These methods allow prescribing the desired body weight as well as performance optimization and monitoring of the effects of training among athletes (27). In this sense, the conventional means for assessing the thickness of skinfolds measured in various anatomical regions are used as variables that predict the percentage of body fat. These values are often required for regression equations from which it is possible to predict a subject's percentage of body fat based on age and sex.

In fact, the equations by Faulkner (8), Durnin and Wormersley (5), Boileau, Lohman, and Slaughter (1), and Slaughter et al. (28) have been used in a number of studies to estimate body composition of young soccer players independent of the position played (9,17,24,25). However, these equations are not specific to soccer players and, from our point of view, no national or international study has proposed specific equations for the percentage of body fat in goalkeepers and other soccer camp players. In spite of this, the literature maintains that soccer players in general are not homogeneous in terms of size and body composition (22). Therefore, the use of one single equation for all soccer players does not reflect the actual percentage of body fat.

The purpose of this study was compare the percentage of fat between players in different positions and, second, to propose specific equations to compare goalkeepers and other soccer camp players using the standard method of Dual-Energy X-Ray Absorptiometry.

METHODS

Subjects

Convenience sampling was used to select 163 young soccer players training for different positions from a professional club in Sao Paulo (Brazil). The players' chronological ages ranged from 11.0 to 18.9 yrs (14.74 ± 2.36 yrs). The sample exhibits a balanced proportion of participants according to age: for example, (11.0 to 11.9 yrs: 12(7.4%); 12.0 to 12.9 yrs: 18(11.0%); 13.0 to 13.9 yrs: 23(14.1%); 14.0 to 14.9 yrs: 25(15.3%); 15.0 to 15.9 yrs: 29(17.8%); 16.0 to 16.9 yrs: 23(14.1%);

17.0 to 17.9 yrs: 15(9.2%); and 18.0 to 18.9 yrs: 8(11.0%). Fifteen percent of the players were Black and 85% were White. Race was determined by skin color.

Research subjects less than 13.9 yrs of age trained 60 to 90 min·d⁻¹ (one competition length) 4 times·wk⁻¹. They had 3 yrs experience training in the sport. The participants who were 14.0 to 16.9 yrs of age trained 5 times·wk⁻¹ for 90 to 120 min·d⁻¹ (one competition). These players had 5 yrs of experience training. Players older than 17.0 yrs trained 6 times·wk⁻¹ for 90 to 120 min·d⁻¹ (one competition). These players had 6 yrs experience training in soccer.

After verbal and written explanations of the research design and risks of the study were explained, parents, and/or individuals of age responsible for the minors provided written informed consent. Players older than age 18 signed their own informed consent forms. The research study was approved by the Research Ethics Committee from the Faculty of Medical Sciences of the Universidad Estadual de Campinas (Brazil). All assessments followed the ethical norms of the Helsinki Declaration.

All players with a minimum of 3 yrs of training experience in soccer and those between the ages of 11.0 and 18.9 yrs of age were included in the study. At the time of the assessment, injured soccer players and those not providing informed consent were excluded.

All measurements were taken in the same club location in a closed laboratory with a room temperature of 24° C in February 2014 between 9:00 and 11:00 am. The players wore light clothing that consisted of a shirt and short pants. Anthropometric measurements were taken first, and, then, the DXA scan was performed. All measurements were taken prior to training. The players were advised of the protocols that were to be followed during the experiment.

Anthropometry

The anthropometric measurements were taken according to the protocol of the International Society for Advancement of Kinanthropometry (16). All measurements were taken twice by two ISAK certified evaluators. The technical margin of measurement error was less than 2% for weight, height, and sitting height (or trunk length).

The players' body mass (kg) was measured barefoot by using a scale (SECA, Hamburg) with a precision of 0.1 kg. While the players' head was maintained in the Frankfurt plane, height was measured with an stadiometer (SECA, Hamburg) with an accuracy of 0.1 cm. Sitting height was measured with an stadiometer (SECA, Hamburg) with a precision of 0.1 cm while the individual was seated in an upright position on a wooden bench (a flat box with a height of 50 cm). The skinfold measurements of the triceps, biceps, subscapular, suprailiac, thigh, and mid-calf were measured with a skinfold caliper (Harpenden, England) whose springs exerted a constant pressure of 10 g·mm⁻².

Maturity

The years from attainment of peak height velocity (APHV) was determined from a sex-specific equation based on Canadian and Belgian boys (20). The biological maturation index predicts years from peak height velocity (PHV) as a measure of maturity-offset according to the following equation: $-9.236 + 0.0002708 (\text{leg length} \times \text{sitting height}) - 0.001663 (\text{age} \times \text{leg length}) + 0.007216 (\text{age} \times \text{sitting height}) + 0.02292 (\text{weight by height ratio})$, where $R = 0.94$, $R^2 = 0.89$, and Standard Error of Estimation (SEE) = 0.59. Measurement lengths are in centimeters and weight measurements are in kilograms. The weight by height ratio is multiplied by 100.

DXA Measurements

All subjects were advised not to wear any jewelry or to have any metal on their bodies during the scanning process. For the scans, the Dual-Energy X-Ray Absorptiometry (Lunar Prodigy; General Electric, Fairfield, CT) was used. Individual subjects were positioned within the scanning area in a supine position with the arms positioned and pronated to the side of the body. Fingers and toes were pointed, and ankles were fastened together with a Velcro belt to ensure standard positioning.

All subjects were told that during the total body scan (5 min) measurement, they needed to remain still. A trained and experienced technician was in charge of the measurement process. Moreover, in keeping with the manufacturer's instructions, the density meter was calibrated daily. To verify the reproducibility capability (test and pre-test), the scan was repeated on 10 soccer players. The intra-evaluator measure of technical error was less than 1.5%.

Groups Studied

Soccer players were grouped according to the position they played: (a) Goalkeepers; (b) Side defenders; (c) Central defenders; (d) Central mid-fielders; (e) Side mid-fielders; and (f) Attackers. Furthermore, another group was created whereby the Side defenders, Central defenders, Central mid-fielders, Side mid-fielders, and Attacker were all joined together to form the group labeled as the Soccer Camp players.

Statistical Analyses

The regularity of all the variables was verified by the Kolmogorov-Smirnov test. All of the variables showed a satisfactory pattern. To analyze the data, descriptive statistics were used to describe the arithmetic mean and standard deviation. Differences between the players' positions were verified by the one-way ANOVA. If a significant F-value was observed, a Tukey *post hoc* test was used to identify the points of difference. Differences between goalkeepers and soccer camp players were verified by using the *t* test for independent samples.

Regression analysis by steps (simple and multiple) was used to evaluate the combination of anthropometric variables that helped predict the percentage of fat by DXA. The variance inflation factor (VIF) was used to select the equations by identifying R², SEE, and multicollinearity. Equations were selected by identifying R², SEE, and multicollinearity by means of the variance inflation factor (VIF). Previously, Pearson's coefficient was used to evaluate the relationship between the predictor variables and the dependent variable (percentage of DXA fat). In all cases, the probability of $P < 0.001$ was adopted. The entire statistical analysis was completed on Excel spreadsheets and by using SPSS 18.0.

RESULTS

Table 1 illustrates the variables that describe the sample studied. Goalkeepers and Side defenders showed greater weight, height, and sitting height in relation to the other positions ($P < 0.001$). In general, the Central defenders demonstrated greater lean mass. The Goalkeepers possessed a greater percentage of fat and body fat as compared to the other positions ($P < 0.001$). As for bone mass, the Side mid-fielders showed lesser values with respect to Goalkeepers and Central defenders ($P < 0.05$). No differences in chronological age and APVC emerged between players' positions ($P > 0.05$).

Table 1. Anthropometric Characteristics of Soccer Players by Age and Playing Position.

Variables	Goalkeepers (n=22)		Side Defenders (n = 27)		Central Defenders (n = 22)		Central Mid- Fielders (n = 31)		Side Mid- Fielders (n = 32)		Attackers (n = 29)		All (n = 163)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Age (yr)	14.7	2.5	14.6	2.2	15.7	2	15.2	2.4	15.3	2.8	15.1	2.5	15.1	2.4
Weight (kg)	69.3	15.1	56.8	13.5 ^a	69.7	10.1 ^b	61.9	12.9 ^{ac}	55.1	10.5 ^{ac}	61.3	14.1 ^{ac}	61.6	13.7
Height (cm)	177.7	13	165.8	11.7 ^a	175.2	22.5 ^b	165.4	20.6 ^{ac}	164.2	11.7 ^{ac}	168	13.5 ^{ac}	168.7	16.4
ATC (cm)	90.5	7.7	85.5	6.5 ^a	92.4	4.8 ^b	87.7	6.1 ^{ac}	85.1	5.9 ^{ac}	86.8	6.7 ^{ac}	87.7	6.7
APVC (yr)	0.49	2.15	-0.22	1.76	1.2	1.59	0.37	1.89	0.05	1.98	0.16	1.93	0.3	1.91
Body Fat percentage (Dexa)	21.5	7.5	16.9	3.8 ^a	17	3.5 ^a	18	5.9 ^a	17.7	0.5 ^a	16.8	4.2 ^a	17.9	5.3
Bone Mass (kg)	3.2	0.85	2.6	0.7 ^{ac}	3.2	0.6	2.78	0.7	2.5	0.6	2.8	0.7	2.7	0.7
Body Fat (kg)	14.31	4.9	8.9	2.6 ^a	11.2	2.4 ^a	10.5	3.3 ^a	9.0	1.9 ^a	10.2	2.7 ^a	10.4	3.4
Lean Mass (kg)	51.8	16.7	45.3	11.3	55.3	8.5 ^{abdef}	48.7	11.2	43.7	9.8	48.3	14.9	47.9	12.6

SD = standard deviation; **a** = significant difference in relation to Goalkeepers; **b** = significant difference in relation to Side defenders; **c** = significant difference in relation to Central defenders; **d** = significant difference in relation to Central mid-fielders; **e** = significant difference in relation to Side mid-fielders; **f** = significant difference in relation to Attackers

The anthropometric characteristics and body composition of the Goalkeepers and Soccer Camp players (Side defenders, Central defenders, Central mid-fielders, Side mid-fielders, Attackers) are depicted in Table 2. The Goalkeepers showed greater weight, height, fatty tissue (triceps, suprailiac, abdominal, muscle, and mid-calf skin folds), and body fat in comparison to the Soccer Camp players ($P < 0.001$). No differences occurred in age, sitting height, APVC, bicep and subscapular skin folds, bone mass, and lean mass ($P > 0.001$).

Table 2. Anthropometric Differences and Body Composition between Goalkeepers and Soccer Camp Players.

Variables	Goalkeepers (n = 22)		Soccer Camp Players (n = 141)	
	Mean	±SD	Mean	±SD
Age (yr)	14.7	2.5	15.2	2.4
Weight (kg)	69.3	15.1	60.5	13.1 ^{**}
Height (cm)	177.7	13.0	167.3	16.5 ^{**}
Sitting Height (cm)	90.5	7.7	87.2	6.5 [*]
APVC (yr)	0.5	2.2	0.3	1.9
Skinfolds (mm)				
Biceps	2.8	2.4	2.5	0.8
Triceps	9.0	5.1	6.8	2.8 [*]
Sub-Scapular	8.5	3.7	6.8	1.6
Suprailiac	10.6	6.3	6.9	2.9 ^{**}
Abdominal	12.9	8.5	7.5	2.9 ^{**}
Muscle	11.1	6.4	8.5	4.1 ^{**}
Calf	5.5	4.1	3.8	1.8 [*]
Body Fat Percentage (Dexa)	21.5	7.5	17.3	4.6 ^{**}
Bone Mass (kg)	3.2	0.85	2.7	0.7
Fat Mass (kg)	14.31	4.9	9.8	2.7 ^{**}
Lean Mass (kg)	51.8	16.7	47.6	11.8

Legend: * = ($P < 0.05$), ** = ($P < 0.001$), **SD** = standard deviation.

Table 3 depicts the regression equations proposed to predict the percentage of body fat of young soccer players. Both groups showed values of $P < 0.001$. The first two equations of both groups have age and skinfolds (suprailiac and abdominal) in common as predictors. However, in the third equation (for both groups), when a third skin fold was added, the R^2 increased from 2% to 4%, the SEE values diminished .06% to .35%, and the values of the factor of inflation variance oscillated from 1.38 to 6.18 for Goalkeepers and between 1.09 to 5.18 for Soccer Camp players.

Table 3. Regression Equations to Predict the Percentage of Body Fat in Young Goalkeepers and Soccer Camp Players.

Nº Equations		VIF						R ²	SEE	P
		Yr	SI	Ab	T	MC	R			
Goalkeepers										
1	17.15-0.458(Yr) + 0.665(Si)+0.732(Mc)	1.38	2.28	--	--	2.84	0.961	0.912	2.24	.000
2	22.38-0.765(Yr)+0.52(Ab)+0.662(Mc)	1.58	--	2.25	--	2.94	0.969	0.928	2.01	.000
3	20.38-0.695(Yr)+0.298(Si)+0.344(Ab)+0.595(Mc)	1.63	6.18	6.13	--	3.08	0.974	0.937	1.89	.000
Soccer Camp Players										
1	22.44-0.868(Yr)+0.602(Si)+0.455(T)	1.09	2.03	--	2.06	--	0.865	0.742	2.34	.000
2	22.040-0.823(Yr)+0.440(Ab)+0.518(T)	1.09	--	2.25	2.30	--	0.845	0.711	2.29	.000
3	22.46-0.866(Yr)+0.642(Si)-0.055(Ab)+0.464(T)	1.10	4.66	5.18	2.37	--	0.865	0.750	2.28	.000

Legend: **FIV** = Factor of Inflation Variance, **SEE** = Standard Estimation Error, **Si** = Supra-iliac, **Ab** = Abdominal, **T** = Thigh, **Mc** = Mid-calf, **Yr** = Chronological age

Figure 1 shows the differences between the equations generated with the reference (percentage of fat by DEXA). No significant differences were found in any case ($P > 0.001$). The six equations showed similar values in the percentage of fat in relation to the reference (DEXA).

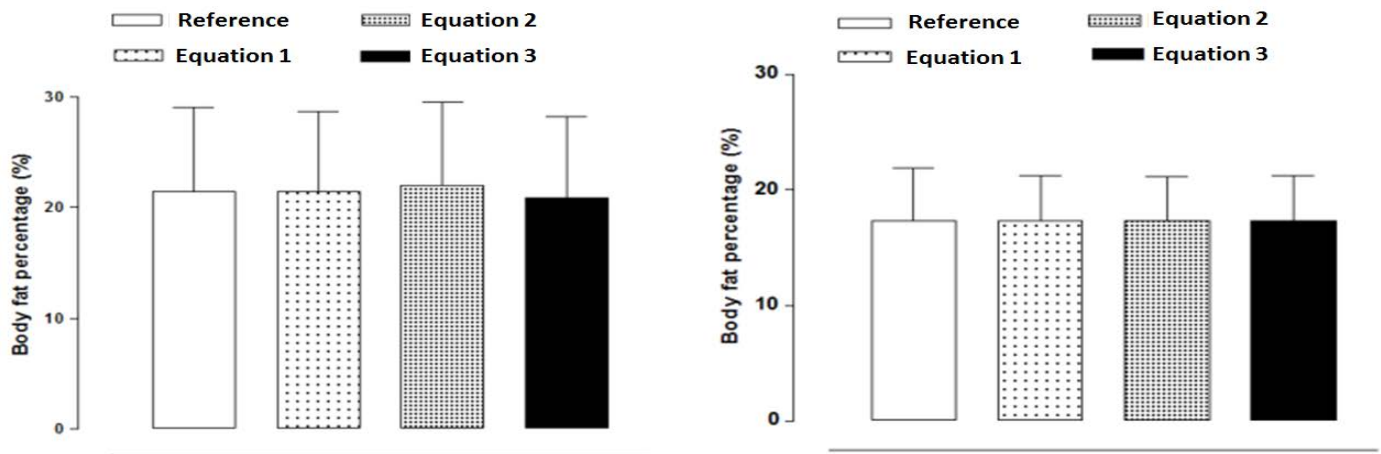


Figure 1. Comparison of Percentage of Body Fat between the Reference Method (DEXA) and New Equations Generated for Goalkeepers and Soccer Camp ($P > 0.001$).

DISCUSSION

The results of this research study demonstrated that the Goalkeepers had a greater percentage of body fat compared to the rest of the soccer players in different positions. This difference remained even when specific Soccer Camp players' positions were compared. This included the five specific positions (side defenders, central defenders, central mid-fielders, side mid-fielders, and attackers).

In spite of the existence of few studies focusing on the positions played by young soccer players, in this context, the results of our research are consistent with those of some authors. For example, the work of Lago-Peñas and colleagues (17) showed differences in the percentage of body fat between Goalkeepers and mid-fielders and attackers. On the other hand, Gil et al. (12) only observed differences with the attackers. However, in their recent study of young Spanish soccer players, Gil et al. (13) confirmed that Goalkeepers are taller, heavier, and showed greater percentage of fat compared to the field soccer players.

In fact, both anthropometric and body composition differences between the positions of elite adult soccer players are widely documented in the literature (11,19,30). In this sense, the pattern observed in the present study reflects clearly that Goalkeepers and Soccer Camp players present anthropometric and body composition characteristics specifically from very early ages. Therefore, during the selection and talent identification processes, the variables of weight, height, and percentage of fat may play a relevant role among the players.

Based on the results from this research study, 6 regression equations were developed specifically to estimate the percentage of body fat of soccer players (3 for Goalkeepers and 3 for Soccer Camp players). The first two equations for both groups use in common the variables of age and the suprailiac and abdominal skinfolds. However, the third equation for both groups uses skinfold from the lower extremity. In this case, the mid-calf skin fold was a strong predictor of the percentage of body fat for Goalkeepers while the muscle skin fold was for the soccer camp players.

Previous studies have shown that the skinfolds from the muscle and the mid-calf (7,31) are strong predictors in non-athletic men as well as women since both skinfolds are found to be present in the equations that predict the percentage of body fat. These results reinforce our findings since both skinfolds were found in the 6 equations we proposed. Therefore, combining the suprailiac and abdominal skinfolds allowed us to improve the R^2 from 2% to 4% while the SEE is decreased in both groups.

In general, the results provide valuable information. In addition to including skinfolds from the central region of the body, it is necessary to use at least one skinfold from the lower extremity in order to predict the percentage of body fat of young soccer players. However, it is important to point out that according to Van der Ploeg et al. (31), researchers should include a variety of anatomical regions that cover the entire body.

Furthermore, biological maturation determined by means of the APVC did not emerge as a predictor of the percentage of body fat in both groups studied. In fact, this was apparently not the case in this research since the skinfolds of the biceps, triceps, subscapular, and the combination of all of them could not overcome the power of explanation of the 6 equations developed. Furthermore, biological maturation determined through the APVC did not emerge as a predictor of percentage of body fat in both groups studied. However, chronological age related best, so it was necessary to include it in the equations.

For future studies, we suggest that other biological maturation indicators be used. Thus, it would be possible to control this variable since during adolescence young athletes and non-athletes experience various anatomical, physiological, and psychological changes. Above all, these need to be taken into account when studying youth engaged in training programs while undergoing growth and development processes.

Therefore, the equations we are proposing here for Goalkeepers and Soccer Camp players showed an R^2 between 71% and 94% similar to various studies carried out on adult soccer players (21,22,26). Moreover, the SEE for the 6 equations was less than the 3% established as criteria by Lhoman (18). Furthermore, the VIF values were well below those set, up to a maximum of 10, by Guo, Chumlea, and Cockran (15). The 6 equations proposed for both groups could be useful for coaches, exercise physiologists, and/or trainers in order to control the body composition before, during, and after the competitive season. Furthermore, no significant differences were found between Goalkeepers and Soccer Camp players when the 3 equations were compared to the reference (percentage of fat by DEXA). However, it should be noted that the equations that included 3 skinfolds are the ones that best predict the percentage of body fat of both groups (Goalkeepers $R^2=0.94$, Soccer Camp players $R^2= 0.75$). Moreover, the SEE for the equations were less than those of the other equations proposed (SEE= 1.89% and 2.28%).

It is important to point out that to date no consensus exists with respect to the optimal means (equations) of predicting the percentage of body fat of youth during the growth period. However, some studies do include the significance values (P) (2,14,32), the R^2 values (3,10), and they even highlight the values for the SEE (29) as basic criteria for selecting an equation. In fact, in this study, we opted to take into account the three criteria. That way, in this study, the risks that might emerge in each equation proposed here could be minimized.

From our point of view, since this is the first research conducted studying young soccer players that proposes equations for percentage of fat, the possible contributions it presents need to be recognized. Some examples worth noting include the low technical measurement error in the anthropometric assessments and the DEXA scans. These guarantee a high ability to reproduce the equations proposed. Furthermore, the calculation procedures imply the use of simple variables (i.e., they have low investment costs). On the other hand, it is necessary to point out some limitations that occurred during the study since the type of sample selection used (non-probabilistic) and the absence of cross validation of the equations could possibly prevent generalization (generalizability) to soccer players at other latitudes. For future research, we suggest that these aspects be controlled for since their fundamental purpose is to minimize errors and maximize the computational accuracy until finding the right method.

CONCLUSION

The goalkeepers and the soccer camp players showed between them different anthropometric characteristics and a specific percentage of body fat. Furthermore, the 6 equations generated may be used to estimate the percentage of body fat for Goalkeepers as well as Soccer camp players. The findings from this study suggest that these equations may be used and applied to young soccer players between the ages of 11.0 and 18.9 yrs.

Address for correspondence: Marco Cossio Bolaños: Av. San Miguel s/n. Talca, Chile, Email: mcossio1972@hotmail.com

REFERENCES

1. Boileau RA, Lohman TG, Slaughter MH. Exercise and body composition in children and youth. *Scand J Med Sci Sports*. 1985;7:17-27.
2. Bray GA, DeLany JP, Harsha DW, Volaufova J, Champagne CC. Evaluation of body fat in fatter and leaner 10-y-old African American and white children: The Baton Rouge Children's Study. *Am J Clin Nutr*. 2001;73:687-702.
3. Cameron N, Griffiths PL, Wright MM, Blencowe C, Davis NC, Pettifor JM, Norris SA. Regression equations to estimate percentage body fat in African prepubertal children aged 9 y. *Am J Clin Nutr*. 2004;80:70-75.
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(5):1332-1339.
5. Durnin JVGR, Wormersley J. Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 years. *Bri J Nutr*. 1974;32:77-97.
6. España-Romero V, Ruiz JR, Ortega FB, Artero EG, Vicente-Rodríguez G, Moreno LA, Castillo MJ, Gutierrez A. Body fat measurement in elite sport climbers: Comparison of skinfold thickness equations with dual energy x-ray absorptiometry. *J Sports Sci*. 2009;27(5):469-477.
7. Eston RG, Rowlands AV, Charlesworth S, Davies A, Hoppitt T. Prediction of DXA-determined whole body fat from skinfolds: Importance of including skinfolds from the thigh and calf in young, healthy men and women. *Eur J Clin Nutr*. 2005;59:695-702.
8. Faulkner JA. *Physiology of swimming and diving*. In: *Human Exercise Physiology*. H. Falls, (Ed). Baltimore, MD: Academic Press, 1968, pp. 87-95.
9. Gall F, Carling C, Williams M, Reilly T. Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. *J Sci Med Sport*. 2010;13:90-95.
10. Gartner A, Dioum A, Delpuech F, Maire B, Schutz Y. Use of hand-to-hand impedancemetry to predict body composition of African women as measured by air displacement plethysmography. *Eur J Clin Nutr*. 2004; 58: 523–531. doi: doi:10.1038/sj.ejcn.1601839
11. Gerosa-Neto J, Rossi FE, Buonani-Silva C, Zapatterra-Campos E, Araujo-Fernandes R, Forte-Freitas JI. Body composition analysis of athletes from the elite of Brazilian soccer players. *Motricidade*. 2014;10(4):105-110.

12. Gil SM, Gil J, Ruiz F, Irazusta A, Irazusta J. Physiological and anthropometric characteristics of young soccer players according to their playing position: Relevance for the selection process. **J Strength Cond Res.** 2007;21(2):438-445.
13. Gil SM, Zabala-Lili J, Bidaurrezaga-Letona I, Aduna B, Lekue JA, Santos-Concejero J, Granados C. Talent identification and selection process of outfield players and goalkeepers in a professional soccer club. **J Sports Sci.** 2014;32:20:1931-1939.
14. Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G. Cross-calibration of body composition techniques against dual-energy x-ray absorptiometry in young children. **Am J Clin Nutr.** 1996;63:299-305.
15. Guo SS, Chumlea WC, Cockram DB. Use of statistical methods to estimate body composition. **Am J Clin Nutr.** 1996;64(Suppl. 3):428Se35S.
16. *International Society for Advancement of Kinanthropometry.* International standards for anthropometric assessment. Potchefstroom, RSA:ISAK, 2001.
17. Lago-Peñas C, Casais L, Della A, Rey E, Domínguez E. Anthropometric and physiological characteristics of young soccer players according to their playing positions: Relevance for competition success. **J Strength Cond Res.** 2011;25(12):3358-3367.
18. Lohman TG. *Dual energy X-ray absorptiometry.* In: **Human Body Composition**, (Eds) AF Roche, SB Heymsfield & TG Lohman. Champaign, IL: Human Kinetics, 1966, pp. 63-78.
19. Matkovic BR, Misigoj-Durakovic M, Matkovic B, Jankovic S, Ruzic L, Leko G, Kondric M. Morphological differences of elite croatian soccer players according to the team position. **CollAntropol.** 2003;27(1):167-174.
20. Mirwald RL, Baxter-Jones AB, Bailey AD, Beunen GP. An assessment of maturity from anthropometric measurements. **Med Sci Sports Exerc.** 2002;34:689-694.
21. Novack LF, Assunção-Ferreira G, Coelho RL, Osiecki R. Novel equations to predict body fat percentage of Brazilian professional soccer players: A case study. **Motriz Rio Claro.** 2014;20(4):402-407.
22. Oliver JM, Lambert BS, Martin M, Green JS, Crouse SF. Predicting football players' dual-energy x-ray absorptiometry body composition using standard anthropometric measures. **J Athl Train.** 2012;47(3):257-263.
23. Parker L, Reilly JJ, Slater C, Wells JC, Pitsiladis Y. Validity of six field and laboratory methods for measurement of body composition in boys. **Obes Res.** 2003;11:852-858
24. Perroni F, Vetrano M, Rainoldi A, Guidetti L, Baldari C. Relationship among explosive power, body fat, fat free mass and pubertal development in youth soccer players: A preliminary study. **Sport Sci Health.** 2014;10:67-73.
25. Portella D, Arruda M, Cossio-Bolaños MA. Valoración del rendimiento físico de jóvenes futbolistas en función de la edad cronológica. **Apunts Educación Física y Deportes.** 2011;106(4):42-49.

26. Reilly T, George K, Marfell-Jones M, Scott M, Sutton L, Wallace J.A. How well do skinfold equations predict percent body fat in elite soccer players? *Int J Sports Med.* 2009;30:607-613.
27. Silva AM, Minderico CM, Teixeira PJ, Pietrobelli A, Sardinha LB. Body fat measurement in adolescent athletes: Multicompartment molecular model comparison. *Eur J Clin Nutr.* 2006; 60:955-964.
28. Slaughter MH, Lohman TG, Boileau RA, Horswill CA, Stillman RJ, Van Loan MD, Bembien DA. Skinfold equations for estimation of body fatness in children and youth. *Hum Biol.* 1988;60(5):709-723.
29. Stevens J, Cai J, Truesdale CP, Cuttler L, Robinson TN, Roberts AL. Percent body fat prediction equations for 8- to 17-year-old American children. *Pediatr Obes.* 2013;9:260-271.
30. Sutton L, Scott M, Wallace J, Reilly T. Body composition of English Premier League soccer players: Influence of playing position, international status, and ethnicity. *J Sports Sci.* 2009; 27(10):1019-1026.
31. Van der-Ploeg GE, Gunn SM, Withers RT, Modra AC. Use of anthropometric variables to predict relative body fat determined by a four-compartment body composition model. *Eur J Clin Nutr.* 2003;57:1009-1016.
32. Yavari R, McEntee E, McEntee M, Brines M. Anthropometric variables accurately predict dual energy x-ray absorptiometric-derived body composition and can be used to screen for diabetes. *PLoS ONE.* 2011;6:e24017.

Disclaimer

The opinions expressed in **JEPonline** are those of the authors and are not attributable to **JEPonline**, the editorial staff or the ASEP organization.