Motricidade © Edições Desafio Singular
2020, vol. **16**, n. **1**, pp. **28-38** http://dx.doi.org/10.6063/motricidade.15557

Comparação entre avaliação antropometrica e bioimpedância multifrequencial para avaliação da composição corporal em atletas de elite sub-20 do futebol brasileiro

Comparison between anthropometry and multi-frequency bioimpedance for body composition evaluation in Brazilian elite U-20 soccer athletes

Carlos Vinicius Herdy[1,2*], Tiago Figueiredo[2,3], Gabriel Costa e Silva[4,5], Pauliana Valéria Machado Galvão[6], Rodrigo Gomes da Souza Vale[2,7], Roberto Simão[1]

ORIGINAL ARTICLE

ABSTRACT

Young soccer players undertake anthropometric measurements for directing the effectiveness of training programs. However, the use of the eight-electrode electrical bioimpedance method is increasingly being used for the body composition evaluation. The purpose of this study was to compare and correlate body composition, using anthropometric predictive equations, with the use of electrical bioimpedance. Thirty Brazilian high-performance men, players of the U-20 category, participated in the study, while their position in the field was recorded. Anthropometrics were assessed using the predictive equations of Faulkner, Yuhasz, Carter, and Slaughter and electrical bioimpedance. There were no significant differences between methods for anthropometric evaluation, while traditional body composition analysis and bioimpedance showed moderate correlations with respect to the anthropometric protocols, Faulkner ($r = 0.63$, $p<0.01$), Yuhasz ($r = 0.64$, $p<0.01$), Carter ($r = 0.64$, $p<0.01$) and Slaughter ($r = 0.53$, $p<0.01$). According to the present investigation, bioimpedance with eight electrodes can be a reliable tool for the assessment of body composition in young soccer players.

Keywords: Football, Fat Percentage, Electric Impedance, Predictive Equations.

INTRODUCTION

Brazil is one of the greatest creators of football talents in the world, and several Brazilian teams divide players into age categories in order to prepare the younger football players for the professional teams. For this, young people aged from 10 to 20 years undergo long training periods to prepare for the season (Herdy et al., 2015). In this way, clubs hope to sell talented young football players to the European football clubs and use the financial benefit to support the professional players in the teams (Cárdenas-Fernández, Chinchilla-Minguet, & Castillo-Raodríguez, 2017).

The main flaw in the training preparation of very young football players is that during the training plan, the real biological age is not considering in order to achieve higher performance (Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007). Based on this, the athlete's preparation in order to maximize performance is accelerated, with the objective of increasing the rise to the professional category (Lago-Peñas, Casais, Dellal, Rey, & Domínguez, 2011). It is noteworthy that

Manuscript received at November 16th 2018; Accepted at August 2nd 2019

[1] *Programa de Pós Graduação em Educação Física, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.*
[2] *Universidade Estácio de Sá, Rio de Janeiro, Brasil.*
[3] *Department of Sport Science, Exercise and Health, Trás-os-Montes e Alto Douro University, Vila Real, Portugal.*
[4] *Laboratório de Fisiologia e Desempenho Humano, Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brasil.*
[5] *Laboratório de Ciência do Movimento Humano, Colégio Pedro II, Rio de Janeiro, Brasil.*
[6] *Faculdade de Medicina (Campus Serra Talhada), Universidade de Pernambuco, Serra Talhada, Brasil.*
[7] *Laboratório do Exercício e do Esporte (LABEES), Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brasil.*
* *Autor correspondente*: Programa de Pós-Graduação em Educação Física da Universidade Federal do Rio de Janeiro (UFRJ), Rua Carlos Chagas Filho, 540. Rio de Janeiro - RJ, Brasil. CEP: 21941-599.
E-mail: carlosherdy@gmail.com

the daily training of football players do not differ between positions and categories; however, athletes perform differently physical and technical demands in the field (Gil et al., 2007; Herdy et al., 2015; Lago-Peñas et al., 2011), which require individualized training based on the frequent assessment of physical condition (Herdy et al., 2015; Lago-Peñas et al., 2011; Portao et a., 2009; Reilly et al., 2009). Among the parameters that compose the physical condition, the body composition deserves attention because it is one of the major components of physical fitness and can influence sports performance and may be related to the injury risk (Kemper et al., 2015).

The body composition assessment can be used to observe growth patterns and development in young people or to classify the relative body fat (Herdy et al., 2015). Some studies have verified that the process of body composition analysis has been important in the development of the athletic performance of young football players (Herdy et al., 2015; Lago-Peñas et al., 2011; Reilly et al., 2009). For example, Herdy et al. (2016) analyzing the body composition of 1115 football players of different ages, categories, and field positions, to evaluate a morphological profile ofthese athletes and verified that the evolution between the ages occurs constantly.

The most used method for body composition assessment in football players is anthropometry (Fonseca, Marins, & Silva, 2007; Herdy et al., 2015; Kemper et al., 2015), and the majority of anthropometric evaluations are based on predictive protocols, which use-values of body measurements, like subject`s weight, height, skinfolds, bone diameters and limbs circumference in different positions (Herdy et al., 2015; Lago-Peñas et al., 2011). In the above-mentioned anthropometric assessments, a critical factor is the experience of the investigator, the appropriate equipment, and the reproduction of the appropriate protocol for the body composition evaluation (Herdy et al., 2016).

The accuracy during the anthropometric measurement is fundamental for the planning and control of training programs. In this sense, the choice of the best protocol for evaluation young football players is still causing for many doubts and divergences among the football professionals, something which has already been discussed (Both, Matheus, & Behenck, 2015; Demura, Sato, & Kitabayashi, 2004; Fonseca et al., 2007). In this context, bioimpedance (BIA8) has been used as a tool to evaluate the body composition of healthy individuals (Demura et al., 2004), offering fat percentage values, total body water and fat-free muscle mass (Balsalobre-Fernández, Glaister, & Lockey, 2015). Therefore, this tool can be promising equipment for the assessment of football players' body composition, while it is easy in use and very fast in measurement outcomes when compared to anthropometric measurements (Pietrobelli, Rubiano, St-Onge, & Heymsfield, 2004).

The BIA8 has the accuracy in identifying the differences between muscle structures, be it in muscle fiber composition, intracellular and extracellular fluid and has been pointed out in the literature as a possible instrument in the evaluation of the body composition, being necessary only to look for the due care that precedes the day of the evaluation (Bescós, 2009; Demura et al., 2004; Faria, Faria, Cardeal, & Ito, 2014; Finn, Saint-Maurice, Karsai, Ihász, & Csányi, 2015). The widely used and considered the gold standard method for verifying body composition is dual-energy radiological absorptiometry (DXA) (Rodrigopulle & Atkinson, 2014), and has been used to estimate muscle mass and, although it is an indirect method, it is considered an excellent instrument for evaluation of muscle mass in humans and has a high correlation with multi-frequency bioimpedance (Anderson, Erceg, & Schroeder, 2012; Bescós, 2009; Demura et al., 2004; Faria et al., 2014; Finn et al., 2015).

Some studies have observed that several predictive equations demonstrate inconsistencies with methods considered the gold standard for body composition verification (Reilly et al., 2009; Truesdale, Roberts, Cai, Berge, & Stevens, 2016). For example, in a recent study (Suarez-Arrones et al., 2018) was compared eight anthropometric predictive equations for body composition evaluation with the measurement of four-frequency bioimpedance and DXA in 18 adult professional Italian athletes. The results of this study showed a low correlation between the eight predictive equations with bioimpedance (R= 0.36).

It could be speculated that analyzing the results of bioimpedance with higher electrical frequency range (BIA8), can demonstrate more accurate results when compared to other body composition methods. However, there are still gaps in the literature regarding the correlation of bioimpedance with BIA8 and anthropometric methods. Thus, the purpose of this study was to compare and correlate body composition using anthropometric predictive equations with bioelectrical impedance and verify the relationship between age and position in male football players. It was hypothesized that both evaluation methods result in similar results of body composition and has a significant correlation.

METHOD

Participants

Thirty young male football players (Under-20 category) of a club of the Brazilian first division championship participated in the present investigation. They were according to their position in the field: i) goalkeepers, ii) defenders, iii) midfielder, iv) forward. To characterize the sample, the vertical jump power test (Bosco, Luhtanen, & Komi, 1983) and the Yoyo test recovery level II endurance test (Krustrup et al., 2003) were performed. All athletes were healthy and had a history of injuries. The participants read and signed an informed consent form which is in accordance with Administrative Rule 466 of December 12, 2012, of the National Health Council (Guidelines and standards for conducting experiments with human beings), and the project was submitted to the Ethics Committee in Research of the Rio de Janeiro Federal University with the protocol number of 34315478.7.0000.5257.

Procedures

Anthropometric measurements

The environmental conditions during the tests were as follows: ambient temperature between 20-24 °C, barometric pressure between 700-705mmHg, and relative humidity between 28-71%.

All measurements were performed following anthropometric protocols standardized by the International Society for Advancement of Kinanthropometry (ISAK). The subjects were barefoot to measure height and body mass. The stature and the body mass were measured using a stadiometer with a measuring scale of 0.1 cm and a scale to measure the body mass with an accuracy of 100g, respectively, both measurements were made in same equipment WELMY® brand (Model R 110, São Paulo, Brazil). The same investigator performed all the measurements, while the equipment was calibrated according to the manufacturer's guidelines. The intraclass correlation coefficient (ICC) of the measurements was 0.97.

The thickness of the skinfolds was measured in triplicate using a Lange Skinfold Caliper (Beta Technology Incorporated, Cambridge, England) with a precision of 1mm. The skinfolds collected were triceps, subscapular, suprailiac, abdominal, supraspinatus, thigh, calf, pectoral, mid axillary, and bicipital. Body circumferences were collected in antebellum, arm, thigh, calf, abdomen, waist, thorax, and hip. The circumferences of the different body segments were assessed using the aid of metal tape (Type Rosscraft, Vancouver, Canada) with a precision of 1mm, while the bone diameters of bistyloid, biepicondylian, bicondylian and bimalleolar were performed using a bone pachymeter (Type Rosscraft Campbell, Vancouver, Canada) with a precision of 1mm.

The evaluation of the body composition was made using the technique proposed by Rose and Guimarães (De Rose & Guimaraes, 1980), composed of fat mass (Faulkner, 1968), bone mass (Rocha, 1974), residual mass (Würch, 1974) and muscle mass (Matiegka, 1921). To verify the percentage of body fat, four equations were used: Faulkner (Faulkner, 1968), Yuhasz (Yuhasz, 1968), Carter (Carter & Yuhasz, 1984) e Slaughter (Slaughter et al., 1988). Body density was calculated from the SIRI equation (Siri, 1956).

The equations are as follows:

$$\text{Faulkner} = (triceps + \text{suprailiac} + \text{subscapular} + \text{abdominal}) \times 0.153 + 5.783$$
$$\text{Yuhasz} = (subscapular + triceps + thigh + suprailiac + abdominal + pectoral) \times 0.095 + 3.64$$
$$\text{Carter} = (triceps + subscapular + supraspinal + abdominal + thigh + calf) \times 0.1051 + 2.58$$
$$\text{Slaughter} = (triceps + calf) \times 0.735 + 1$$

Bioelectrical impedance analyses measurements

Bioelectrical impedance analysis was performed using the multi-frequency bioimpedance device with eight tactile electrodes (MF-BIA8; InBody 770, Biospace®), following the manufacturer's recommendations with participants wearing shorts and underwear while being in a fasted state for at least 3h before measurement. The athletes did not ingest liquids and urinated and/or defection 30 minutes prior to the start of the test. All the measurements were performed at the same sequence, that is, at the end of the bioimpedance evaluation, the athletes started the anthropometric tests. The athletes did not perform any physical exercise 24 hours before the test, and the tests occurred in a specific evaluation sector of the club. All equipment was properly calibrated prior to testing according to the manufacturer's guidelines. The sample was made for convenience and the quest for young high-achieving players. Players were instructed not to consume alcohol or any type of food prior to testing.

The age and height of the subjects were inserted directly into the instrument before the impedance measurement. Attention was given to the body position of each participant. The arms remained extended, and instructions for contact with the electrodes (holding firmly). The participants were barefooted and were placed on the lower metal plate of the equipment, and they shook hands indicated by the operating manual. Thus, the equipment printed a brief report that includes the impedance measurements for each of the six frequencies and the body composition estimates for each of the five segments (left arm, right arm, trunk, left leg, right leg). This analyzer uses a current alternation of 250 mA at a multi-frequency of 1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, and 1000 kHz. Impedances of the right arm left arm, right leg, left leg, and trunk were performed for all frequencies and total impedance of the body. The value was calculated by adding the segmental impedance of the values.

The variables analyzed were: height (cm), body mass (kg), body mass index (BMI) (kg / m^2), bone mass (kg), visceral fat area (cm^2), total body water (l), body fat (%), abdominal obesity, skeletal muscle mass (kg), intracellular water (l), extracellular water (l), protein mass (kg), fat free mass (kg), basal metabolic rate), fat mass (kg), mineral mass (kg), lean mass (kg) and body cell mass (kg), fat percentage (%). In addition to the analysis of the lean body mass: right arm (kg and%), left arm (kg and%), trunk (kg and%), right leg (kg and%) and left leg (kg and%).

Statistical analyses

Normality and homoscedasticity were verified through the Shapiro-Wilk and Bartlett tests, respectively. One-way ANOVA was used to compare %fat between different body composition methods followed by Tukey post hoc to identify possible differences. The paired Student's t-test was used to evaluate if there was a significant difference between the means of the two methods used (anthropometry and bioimpedance). The Pearson correlation test was used to verify the possible associations between %fat and BIA8 and the different methods of body composition. The Bland and Altman analyses were used to verify the concordance between the tests. Data are presented as mean ± standard deviation (SD) and minimum/maximal values while, and the level of significance was set at p-value < 0.05. The SPSS version 20.0 was used for all analyses (SPSS Inc., Chicago, IL).

RESULTS

The results presented in Table 1 show the descriptive values of the characteristics of the subjects divided by the positions performed in the field. In addition, the subject's height, the sum of nine skinfolds (tricipital, subscapular, supraspinatus, mid axillary, suprailiac, thoracic, abdominal, thigh, calf), somatotype characteristics (endomorphy, mesomorphy, and ectomorphy).

Table 1

Characterization of the sample in morphological and physical.

Variable	Goalkeepers	Defenders	Midfielder	Forward	All
N	2	10	10	8	30
Age (anos)	18±0	18.6±0.70	18.5±0.71	18.38±0.74	18.46±0.68
Height (cm)	189.5±0.71	180.5±7.25	177.80±6.60	171.50±7.62	177.8±8.16
Sum of Skinfolds (mm)	103.5±47.38	111.30±31.24	95.40±23.47	105.50±40.98	103.93±31.64
Mesomorphy	4.78±0.99	4.83±0.69	4.40±0.95	5.80±0.52	4.94±0.91
Endomorphy	2.83±1.34	2.95±0.88	2.79±0.60	3.18±1.14	2.95±0.86
Ectomorphy	3.25±0.90	2.51±0.74	2.76±0.81	1.68±0.52	2.41±0.84
Vertical jump (watt)	2865.65±597.43	2675.83±461.93	2518.81±391.38	2692.58±354.17	2640.61±407.58
*YYTRL2 ($ml.kg^{-1}.min^{-1}$)	51.54±0.36	54.28±2.53	53.95±1.55	53.53±1.85	53.78±2

Legend: YYTRL2 - Yoyo test recovery level II.

Table 2 presents the descriptive results of the different protocols of the percentage values of body fat based on the anthropometric equations and BIA8. It was observed that the data presented a distribution close to the normal curve.

Table 3 shows the comparison between the two body composition methods, anthropometry using the anthropometric method of Faulkner (1984), a protocol widely used in Brazilian football players (Herdy et al., 2016) and the BIA8. The significance test was the t-Student test for dependent samples in the following variables: weight (p=0.73), ideal weight (p=0.94), residual mass (p=0.73), muscle mass (p=0.17), fat mass (p=0.49), lean mass (p=0.52) and bone mass (p=0.99). Table 4 shows that there were no significant differences between the anthropometric protocols and the bioimpedance method.

Table 2

Descriptive results of the percentage of fat in different body composition methods.

Method	Mean (SD)	Minimum	Maximum	p-value(SW)
Faulkner	14.34±2.69	10.53	20.78	0.295
Yuhasz	10.93±2.22	7.73	16.56	0.408
Carter	9.65±2.04	6.26	14.67	0.702
Slaughter	14.16±4.21	6.88	24.52	0.343
BIA8	11.74±3.56	3.00	20.20	0.602

Table 3

Comparison of body composition components by the anthropometric method in comparison to the bioimpedance method.

Variable	Anthropometry (Faulkner)	Electric Impedance (BIA8)	p-value
Weight	74.31±8.08	73.59±7.98	0.73
Ideal weight	74.04±7.48	73.90±8.27	0.94
Residual Mass	17.91±1.95	17.74±1.92	0.73
Muscle mass	35.58±3.68	37.03±4.36	0.17
Fat mass	8.20±2.16	8.65±2.79	0.49
Lean mass	66.11±6.68	64.94±7.46	0.52
Bone mass	12.62±1.43	10.18±1.50	0.99

Table 4

Comparative results between the percentage of fat (% G) with bioimpedance (BIA8) and the different methods of body composition

Protocols	Mean Difference	p-value	*d*
Faulkner	-2.60	0.275	0.73
Yuhasz	0.81	0.986	0.23
Carter	2.09	0.527	0.59
Slaughter	-2.43	0.353	0.68

Legend: d - effect size for BIA8.

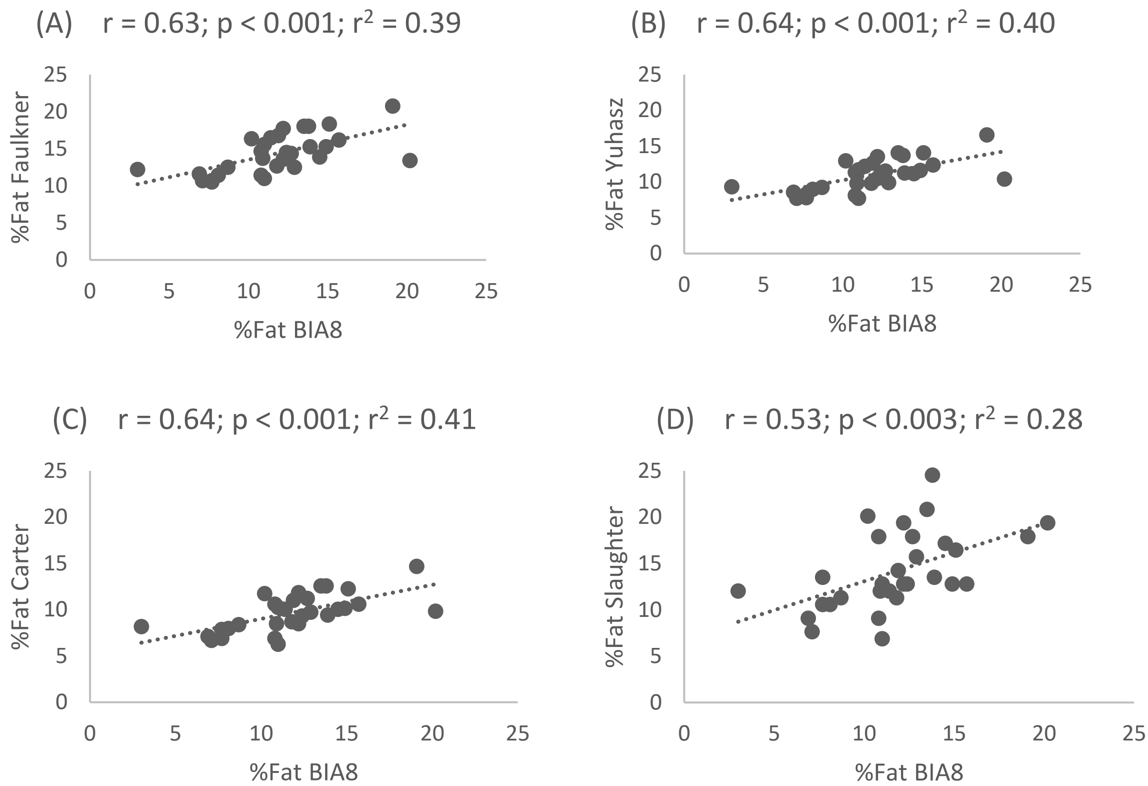

Figure 1. Correlation analysis between fat percentage (% Fat) of Bioimpedance (BIA8) and different body composition methods Faulkner (A), Yushasz (B), Carter (C), and Slaughter (D).

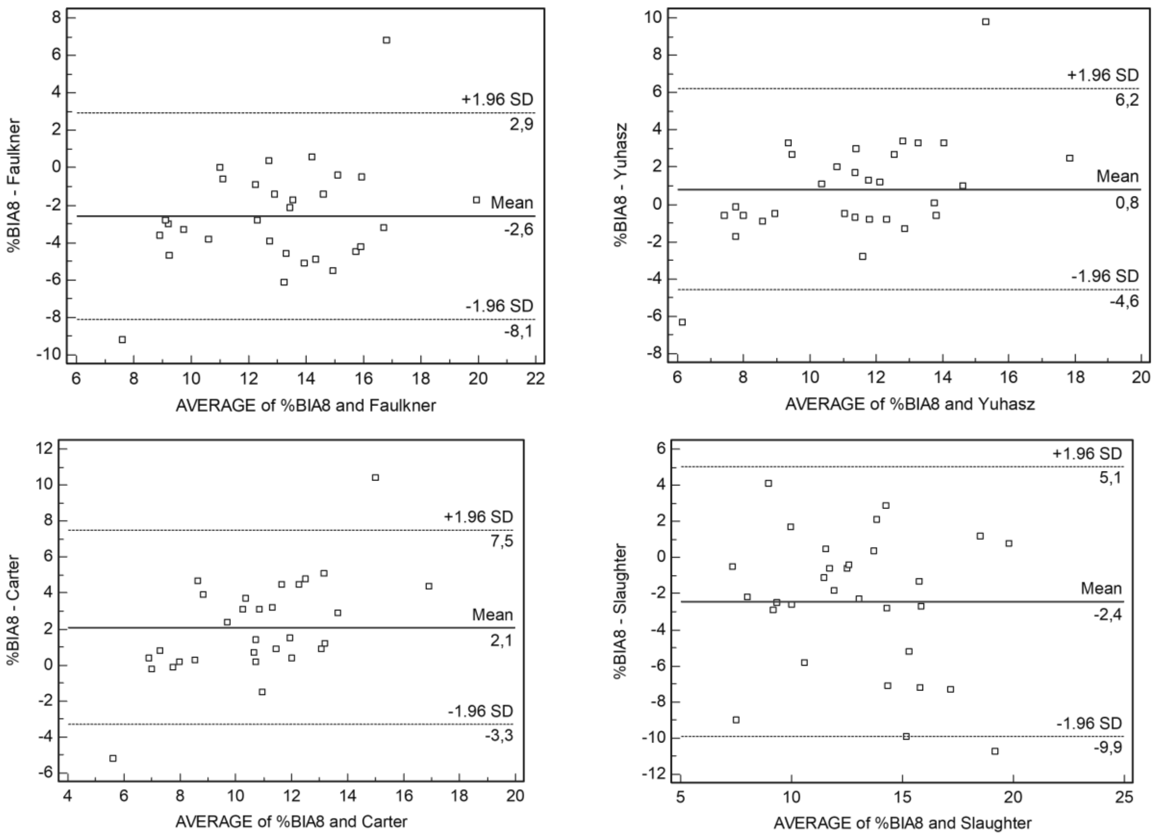

Figure 2. Concordance analysis of the Bland and Altman test between the percentage of fat (%Fat) with bioimpedance (BIA8) and the different body composition methods Faulkner (A), Yushasz (B), Carter (C) and Slaughter (D).

Figure1 shows the fat mass dispersion ratio in its relative format (%), comparing the BIA8 method with the anthropometric methods (10,32,42,44). The results show significant and a moderate correlation between the BIA8 and the predictive equations, r=0.63 (p<0.001); r=0.64 (p<0.001); r=0.64 (p<0.001); and r= 0.53 (p<0.003) for Faulkner, Yuhasz, Carter and Slaughter respectively.

Figure 2. shows the concordance analysis of the Bland and Altman test between the percentage of fat (% G) with bioimpedance (BIA8) and the different body composition methods Faulkner (A), Yushasz (B), Carter (C) and Slaughter (D) respectively

DISCUSSION

The purpose of this study was to compare and correlate body composition using anthropometric predictive equations (Faulkner, Carter, Yuhasz, and Slaughter) with bioelectrical impedance and verify the relationship between age and position in male football players. The main finding of the study was that there was a moderate correlation between the anthropometric equations for estimate body composition and BIA8. In this way, the results of this study confirm the hypothesis that body composition can be evaluated by anthropometric methods or by BIA8 without a significant difference between the methods. In addition, no significant differences were found.

The results relative to a comparison between Faulkner and BIA showed a concordance between anthropometric methods and BIA to estimate body composition compartments. No differences were found to Residual Mass, Muscle Mass, Fat Mass, Lean Mass, and Bone Mass (see Table3). Regarding follow-up measurements in athletes, in order to detect changes in body composition, anthropometry was found to be more sensitive than BIA8 (Portao et al., 2009; Reilly et al., 2009; Truesdale et al., 2016; Langer et al., 2018), while it can be considered as a reliable method for the estimating of body fat, taking into account that the measurement is performed by highly trained professionals (Carter & Yuhasz, 1984; Herdy et al., 2015; Iga, Scott, George, & Drust, 2014; Marra et al., 2019). However, the BIA8 method is an alternative method in case there is no experienced staff and time to accurately perform measurements using different anthropometric parameters (Bescós, 2009).

The concordance analysis of the Bland and Altman test between the percentage of fat (%Fat) with bioimpedance (BIA8) and the different anthropometric equations showed a good concordance between methods, which demonstrate the validation of both to evaluate body composition in football athletes. In the study of Bescós (2009), was used the sophisticated equipment, Biospace Inbody® 770, and the results showed that the equipment has a multi-frequency spectroscopic system of BIA8 (Bescós, 2009). The main characteristic of the device, as opposed to the monofrequency, is that it allows an evaluation with different intensities, which favors a more precise evaluation of the different compartments of body water (Ramírez-Vélez et al., 2018). Studies with equipment that were not equipped with multi-frequency (older equipment) showed significant differences between the estimated fat mass and the skinfold method (Hetzler, Kimura, Haines, Labotz, & Smith, 2006; Leal et al., 2019). Some studies have evaluated the accuracy of BIA8 methods and have observed that the multi-frequency method has greater precision in determining body fat mass percentage when compared to other methods (Demura et al., 2004; Portao et al., 2009).

In the present study, no significant differences were found between the anthropometric predictive equations and the BIA8. In addition, some studies have compared body composition based on anthropometry equations with assessment using BIA8 (Bescós, 2009; Demura et al., 2004; Faria et al., 2014; Finn et al., 2015; Portao et al., 2009) despite the fact that BIA8 is new method along with the high cost of the equipment.

The results of this study showed significant correlations between methods of body composition (See table 2 and Figure1). The best correlations were found to Faulkner (Faulkner, 1968), Yuhasz (Yuhasz, 1968), and Carter (Carter & Yuhasz, 1984) equations (i.e., moderate) relative to BIA8. In accordance with our results, other studies compared body fat using DEXA and anthropometry, it was found that there was a high correlation between the two methods (Milanese, Cavedon, Corradini, De Vita, & Zancanaro, 2015). Moreover, it has been found that there is a high correlation between BIA8 and DEXA (Faria et al., 2014). On the other hand, Reilly et al. (2009) compared existing methods to predict body fat in football players using equations from seven skinfolds (triceps, biceps, supra iliac, supraspinatus, abdominal, thigh, and calf). The body fat of all players was measured using dual-energy radiological absorptiometry (DEXA), which is considered the gold standard method. The results of this study showed a lack of correlation between the skinfolds technique and DEXA.

In an investigation (Gobbo et al., 2008), the validity of the equations developed by Petroski in the estimation of the fat percentage of male college students was analyzed using DEXA (Gobbo et al., 2008; Petroski, 1995). The results pointed to high correlation values ($r \geq 0.90$) and Standard error of estimation lower than 2.6%, however, it was detected that all the Petroski equations overestimated the percentage of body fat, presenting a significant difference.

In another study, Fonseca et al. investigated the validity of equations that estimate body density in 25 adult professional football athletes (18-34y) but, the researchers did not show cross-validity (Fonseca et al., 2007). Similarly, Moura, Rech, Fonseca, and Zinn (2003) evaluated the validity of several anthropometric equations in the estimation of the body composition of 25 football players of the U20 category. Other authors used some equations proposed by Petroski and Guedes, however, as demonstrated in the previous study, the results did not indicate validity for any equation (Both et al., 2015). In a study in the American magazine Childhood Obesity in 2016, the researcher Truesdale, compared eight prediction equations of body composition in youngsters from 8 to 18 years of age, demonstrating that only three equations showed good relations (Truesdale et al., 2016).

Ultimately, it is important to consider some limitations of this study. The protocols of predictive equations known and applied in this study are old but widely used in football (Herdy et al., 2016). Another detail was the number of athletes participating in the present study. It would be important to increase the number of subjects evaluated, as well as subjects from various performance levels.

The results of this study indicated that researchers and exercise professionals should be careful to select the equation protocol to estimate fat percentage in normal young Americans due to biases that should be experienced in young football athletes. Another important detail is the use of the sum of folds, which can be an important measurement for body analysis of football players since it is not recommended to use the Body Mass Index in football, contributing to the questioning of the absence of a specific protocol for professional football players (Reilly et al., 2009). According to the results found for the studied sample, it can be concluded that among the studied equations, a regular correlation was found when compared with the Bioimpedance multi-frequency method. The study suggests the validation of the protocols used to verify the body composition of young football players.

CONCLUSIONS

Throughout this work, we compare the body composition assessment between anthropometry and the multifrequency electric bioimpedance in Brazilian athletes of the U-20 team of a first division club. This study was carried out by the frequency of technological choice of electric bioimpedance equipment with the so-called eight electrodes, which demonstrate a high correlation with the gold standard equipment for validation of measurement. In this way, soccer clubs may soon replace the anthropometric method by method of bioimpedance of eight electrodes, being able to be a world trend of modern soccer. However, in the soccer training process, the equipment does not evaluate the process of the size of body proportions and is specified infield positions. In this way, we hope that our work will serve as a guideline for future professionals who have doubts about which method to use in young soccer players.

Acknowledgments:
Nothing to declare.

Conflict of interests:
Nothing to declare.

Funding:
Nothing to declare.

REFERENCES

Anderson, L. J., Erceg, D. N., & Schroeder, E. T. (2012). Utility of multifrequency bioelectrical impedance compared with dual-energy x-ray absorptiometry for assessment of total and regional body composition varies between men and women. *Nutrition Research, 32*(7), 479-485. https://doi.org/10.1016/j.nutres.2012.05.009

Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of Sports Sciences, 33*(15), 1574-1579. https://doi.org/10.1080/02640414.2014.996184

Bescós, R. (2009). Assessment of Body Fat in Physically Active Young People:anthropometryc vs Bioimpedance. *Nutricion Hospitalaria, 24*(5), 5-6. https://doi.org/10.3305/nh.2009.24.5.4463

Bosco, C., Luhtanen, P., & Komi, P. V. (1983). A simple method for measurement of mechanical power in jumping. *European Journal of Applied Physiology and Occupational Physiology, 50*(2), 273-282.

Both, D. R., Matheus, S. C., & Behenck, M. S. (2015). Validação de equações antropométricas específicas e generalizadas para estimativa do percentual de gordura corporal em estudantes de Educação Física do sexo masculino. *Revista Brasileira de Educação Física e Esporte, 29*(1), 13-23. https://doi.org/10.1590/1807-55092015000100013

Cárdenas-Fernández, V., Chinchilla-Minguet, J. L., & Castillo-Rodríguez, A. (2017). Somatotype and Body Composition in Young Soccer Players According to the Playing Position and Sport Success. *Journal of Strength and Conditioning Research, 33*(7), 1904-1911. https://doi.org/10.1519/JSC.0000000000002125

Carter, J. E. L., & Yuhasz, M. S. (1984). 8. Skinfolds and Body Composition of Olympic Athletes. In J.E.L. Carter (Org.), *Medicine and Sport Science, 18*(1), 144-182. S. Karger AG. https://doi.org/10.1159/000409681

De Rose, E. H., & Guimaraes, A. C. (1980). A model for optimization of somatotype in young athletes. In M. Ostyn, G. Beunen, & J. Simons (Eds.), *Kinanthropometry II* (p. 222). University Park Press.

Demura, S., Sato, S., & Kitabayashi, T. (2004). Percentage of total body fat as estimated by three automatic bioelectrical impedance analyzers. *Journal of Physiological Anthropology and Applied Human Science, 23*(3), 93-99.

Faria, S. L., Faria, O. P., Cardeal, M. D. A., & Ito, M. K. (2014). Validation Study of Multi-Frequency Bioelectrical Impedance with Dual-Energy X-ray Absorptiometry Among Obese Patients. *Obesity Surgery, 24*(9), 1476-1480. https://doi.org/10.1007/s11695-014-1190-5

Faulkner, J. A. (1968). Physiology of swimming and diving. In H. Falls (Ed.), *Exercise physiology* (pp. 415–446). Academic Press.

Finn, K. J., Saint-Maurice, P. F., Karsai, I., Ihász, F., & Csányi, T. (2015). Agreement Between Omron 306 and Biospace InBody 720 Bioelectrical Impedance Analyzers (BIA) in Children and Adolescents. *Research Quarterly for Exercise and Sport, 86*(sup1), S58-S65. https://doi.org/10.1080/02701367.2015.1042998

Fonseca, P. H. S. da, Marins, J. C. B., & Silva, A. T. da. (2007). Validação de equações antropométricas que estimam a densidade corporal em atletas profissionais de futebol. *Revista Brasileira de Medicina do Esporte, 13*(3), 153-156. https://doi.org/10.1590/S1517-86922007000300005

Gil, S. M., Gil, J., Ruiz, F., Irazusta, A., & Irazusta, J. (2007). Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. *Journal of Strength and Conditioning Research, 21*(2), 438-445. https://doi.org/10.1519/R-19995.1

Gobbo, L. A., Cyrino, E. S., Petroski, É. L., Cardoso, J. R., Carvalho, F. O., Romanzini, M., & Avelar, A. (2008). Validation of anthropometric equations for the estimation of muscular mass by dual energy x-ray absorptiometry in male college students. *Revista Brasileira de Medicina do Esporte, 14*(4), 376-380. https://doi.org/10.1590/S1517-86922008000400011

Herdy, C., Alkmim, R., Simão, R., Rodríguez Rodríguez, F., Soares Mattos, D., Ramos, S., Teixeira, R., Costa e Silva, G., Novaes, J. (2015). Perfil antropométrico, composición corporal y somatotipo de jóvenes futbolistas Brasileños de diferentes categorías y posiciones. *Educación Física y Deporte, 34*(2), 507-524. https://doi.org/10.17533/udea.efyd.v34n2a09

Hetzler, R. K., Kimura, I. F., Haines, K., Labotz, M., & Smith, J. (2006). A comparison of bioelectrical impedance and skinfold measurements in determining minimum wrestling weights in high school wrestlers. *Journal of Athletic Training, 41*(1), 46-51.

Iga, J., Scott, M., George, K., & Drust, B. (2014). Seasonal changes in multiple indices of body composition in professional football players.

International Journal of Sports Medicine, 35(12), 994-998. https://doi.org/10.1055/s-0034-1371833

Kemper, G., van der Sluis, A., Brink, M., Visscher, C., Frencken, W., & Elferink-Gemser, M. (2015). Anthropometric Injury Risk Factors in Elite-standard Youth Soccer. *International Journal of Sports Medicine, 36*(13), 1112-1117. https://doi.org/10.1055/s-0035-1555778

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., … Bangsbo, J. (2003). The Yo-Yo Intermittent Recovery Test: Physiological Response, Reliability, and Validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. https://doi.org/10.1249/01.MSS.0000058441.94520.32

Lago-Peñas, C., Casais, L., Dellal, A., Rey, E., & Domínguez, E. (2011). Anthropometric and physiological characteristics of young soccer players according to their playing positions: relevance for competition success. *Journal of Strength and Conditioning Research, 25*(12), 3358-3367. https://doi.org/10.1519/JSC.0b013e318216305d

Langer, R. D., Matias, C. N., Borges, J. H., Cirolini, V. X., Páscoa, M. A., Guerra-Júnior, G., & Gonçalves, E. M. (2018). Accuracy of Bioelectrical Impedance Analysis in Estimated Longitudinal Fat-Free Mass Changes in Male Army Cadets. *Military Medicine, 183*(7-8), e324-e331. https://doi.org/10.1093/milmed/usx223

Leal, L. L. A., Barbosa, G. S. L., Ferreira, R. L. U., Avelino, E. B., Bezerra, A. N., Vale, S. H. de L., & Maciel, B. L. L. (2019). Cross-validation of prediction equations for estimating body composition in ballet dancers. *PloS One, 14*(7), e0219045. https://doi.org/10.1371/journal.pone.0219045

Matiegka, J. (1921). The testing of physical efficiency. *American Journal of Physical Anthropology*, *4*(3), 223–230. https://doi.org/10.1002/ajpa.1330040302

Marra, M., Sammarco, R., De Lorenzo, A., Iellamo, F., Siervo, M., Pietrobelli, A., Donini, L. M., Santarpia, L., Cataldi, M., Pasanisi, F., & Contaldo, F. (2019). Assessment of Body Composition in Health and Disease Using Bioelectrical Impedance Analysis (BIA) and Dual Energy X-Ray Absorptiometry (DXA): A Critical Overview. *Contrast Media & Molecular Imaging, 2019*, 3548284. https://doi.org/10.1155/2019/3548284

Milanese, C., Cavedon, V., Corradini, G., De Vita, F., & Zancanaro, C. (2015). Seasonal DXA-measured body composition changes in professional male soccer players. *Journal of Sports Sciences, 33*(12), 1219-1228. https://doi.org/10.1080/02640414.2015.1022573

Moura, J. A. R. de, Rech, C. R., Fonseca, P. H. S. da, & Zinn, J. L. (2003). Validação de equações para a estimativa da densidade corporal em atletas de futebol categoria sub-20. *Revista Brasileira de Cineantropometria e Desempenho Humano, 5*(2), 22-32.

Petroski, É. L. (1995). *Desenvolvimento e validação de equações generalizadas para a estimativa da densidade corporal em adultos*. Santa Maria: UFSM.

Pietrobelli, A., Rubiano, F., St-Onge, M.-P., & Heymsfield, S. B. (2004). New bioimpedance analysis system: improved phenotyping with whole-body analysis. *European Journal of Clinical Nutrition, 58*(11), 1479-1484. https://doi.org/10.1038/sj.ejcn.1601993

Portao, J., Bescós, R., Irurtia, A., Cacciatori, E., & Vallejo, L. (2009). Assessment of body fat in physically active young people: anthropometry vs bioimpedance. *Nutricion Hospitalaria, 24*(5), 529-534.

Ramírez-Vélez, R., Tordecilla-Sanders, A., Correa-Bautista, J. E., González-Ruíz, K., González-Jiménez, E., Triana-Reina, H. R., García-Hermoso, A., Schmidt-RioValle, J. (2018). Validation of multi-frequency bioelectrical impedance analysis versus dual-energy X-ray absorptiometry to measure body fat percentage in overweight/obese Colombian adults. *American Journal of Human Biology, 30*(1). https://doi.org/10.1002/ajhb.23071

Reilly, T., George, K., Marfell-Jones, M., Scott, M., Sutton, L., & Wallace, J. A. (2009). How well do skinfold equations predict percent body fat in elite soccer players? *International Journal of Sports Medicine, 30*(8), 607-613. https://doi.org/10.1055/s-0029-1202353

Rocha, M. (1974). Peso ósseo do brasileiro de ambos os sexos de 17 a 25 años. *Arquivos de Anatomía e Antropología, 1*(1), 445-451.

Rodrigopulle, D. J., & Atkinson, S. A. (2014). Validation of surrogate limb analysis for body composition in children by dual energy X-ray absorptiometry (DXA). *European Journal of Clinical Nutrition, 68*(6), 653-657. https://doi.org/10.1038/ejcn.2014.44

Siri, W. E. (1956). The gross composition of the body. *Advances in Biological and Medical Physics, 4*(1), 239-280.

Slaughter, M. H., Lohman, T. G., Boileau, R. A., Horswill, C. A., Stillman, R. J., Van Loan, M. D., & Bemben, D. A. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology, 60*(5), 709-723.

Suarez-Arrones, L., Petri, C., Maldonado, R. A., Torreno, N., Munguía-Izquierdo, D., Di Salvo, V., & Méndez-Villanueva, A. (2018). Body fat assessment in elite soccer players: cross-validation of different field methods. *Science and Medicine in Football, 2*(3), 203-208. https://doi.org/10.1080/24733938.2018.1445871

Truesdale, K. P., Roberts, A., Cai, J., Berge, J. M., & Stevens, J. (2016). Comparison of Eight Equations That Predict Percent Body Fat Using Skinfolds in American Youth. *Childhood Obesity*

(Print), *12*(4), 314-323. https://doi.org/10.1089/chi.2015.0020

Withers, R. T., Craig, N. P., Bourdon, P. C., & Norton, K. I. (1987). Relative body fat and anthropometric prediction of body density of male athletes. *European Journal of Applied Physiology and Occupational Physiology, 56*(2), 191-200.

Würch, A. (1974). La femme et le sport. *Mèdicine Sportive, París, 4*(1), 1.

Yuhasz, M. (1968). *Physical fitness Manual. London*, Ontario: University of Western Ontario.