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Body Composition Assessment of University Athletes: Comparison Between the Data Obtained by Bioelectrical Impedance and by Anthropometry

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Resumen

Objetivo: Comparar los valores obtenidos de los métodos prácticos más utilizados en la práctica clínica, por impedancia bioeléctrica y por antropometría de la composición corporal de deportistas universitarios. **Métodos:** Estudio analítico observacional cuya muestra incluyó 26 atletas de un equipo de fútbol universitario portugués. La evaluación de la composición corporal de los individuos fue ejecutada a través de bioimpedancia eléctrica y antropometría por un antropometrista ISAK nivel uno acreditado completando el protocolo inherente. Para el análisis de los datos se consideró un nivel de significación crítico del 5% para un nivel de confianza del 95% para contrastar las hipótesis entre las variables en estudio y sus correlaciones, se aplicó la prueba paramétrica de coeficiente de correlación lineal de Pearson. **Resultados:** Se destaca la variabilidad de la composición corporal evaluada en la muestra. Se encontraron correlaciones significativas para la masa grasa y la suma de los pliegues cutáneos (r=0,782; p=<0,001), así como para los pliegues cutáneos individuales. Respectivamente mediante la elaboración del diagrama de dispersión se obtuvo el siguiente r2= 0.612 lineal, que representa la correlación entre las variables. Se encontraron correlaciones similares en el contexto de la masa libre de grasa y las circunferencias. Sin embargo, en el caso de la relación cintura-cadera evaluada por bioimpedancia eléctrica y la relación cintura-cadera evaluada por antropometría, hubo correlaciones menores en comparación con los demás parámetros evaluados (r=0,441; p=0,036). **Conclusión:** Se pretende facilitar a los profesionales del deporte interesados la selección de métodos prácticos para evaluar la composición corporal de sus atletas, eliminando al mismo tiempo el riesgo de seleccionar métodos inapropiados. Se destaca la posibilidad de sustituir o complementar el análisis de bioimpedancia eléctrica con un método antropométrico accesible y viable como es la suma de pliegues cutáneos, especialmente en equipos de menor presupuesto como los equipos universitarios.

Palabras Clave: Atletas universitarios, Composición corporal, Impedancia bioeléctrica, Antropometría

Abstract

Introduction: To compare the values obtained of the most used practical methods in clinical practice, by bioelectrical impedance and by anthropometry of the body composition of university athletes. **Methods:** Observational analytical study whose sample included 26 athletes of a Portuguese university football team. The assessment of individuals' body composition was executed through bioelectrical impedance and anthropometry by an ISAK level one anthropometrist accredited completing the inherent protocol. For the data analysis was considered a critical significance level of 5% for a confidence level of 95% to test the hypotheses between the variables under study and their correlations, Pearson's parametric test of linear correlation coefficient was applied.

Results: The variability of body composition assessed in the sample is highlighted. Significant correlations were found for fat mass and skinfolds sum (r=0,782; p=<0,001) as well as for individual skinfolds. Respectively through the elaboration of the scatter diagram, the following linear r^2= 0.612 was obtained, representing the correlation between the variables. Similar correlations were found in the context of fat free mass and circumferences. However, in the case of the waist-to-hip ratio assessed by electrical bioimpedance and the waist-to-hip ratio assessed by anthropometry, there were lower correlations compared to the other parameters evaluated (r=0,441; p=0,036). **Conclusion**: It is intended to make it easier for interested sports professionals to select practical methods for assessing the body composition of their athletes, while eliminating the risk of selecting inappropriate methods. It is noted the possibility of replacing or complementing the bioelectrical impedance analysis with an accessible and viable anthropometric method such as the skinfolds sum, especially in teams with lower budgets like the university teams.

Keywords: University athletes, Body composition, Bioelectrical impedance, Anthropometry

Introducción

University athletes are a specific population, so collaboration and joint work in the sport sciences is important to better understand their particular needs (Egan 2019, Quinaud et al. 2020). Of the various modalities of university sports, the ones that most lead to the integration and inclusion of new athletes are the collective modalities (Wu and Ke 2022). As an example of collective modalities is football. Team modalities, as a general rule, are called intermittent sports where there are high-intensity actions interspersed with low-intensity actions. In terms of skills inherent to the various athletes, there is often a balance, on the one hand, between the technical-tactical capacity and quality and, on the other hand, the physical component (Dodd and Newans 2018).

Regarding the physical component interpreted as body composition, it is reflected as an important factor in determining basal metabolism. Skeletal muscle mass (SMM) contributes 13 kcal/kg while fat mass (FM) only 4.5 kcal/kg, it can be said that resting muscle spends three times more calories than fat. Although from a relative point of view it appears to have a great influence, from an absolute point of view it is not necessarily due to other parameters that interfere with basal metabolism such as genetic components, age and gender (Amaro-Gahete et al. 2020).

From the perspective of total energy requirements, the determination of body composition continues to reflect a similar situation. This is because for its calculation comes the value obtained by the basal metabolic rate, being multiplied by the identified activity factor of the athlete (Silva et al. 2018, Smith-Ryan et al. 2020). Additionally, the stress factor can also be included in the equation with an eventual injury, recognizing the athlete's need for rehabilitation and recovery (Smith-Ryan et al. 2020). In view of all these issues, it is necessary to validate the correct methodology for assessing body composition (Campa et al. 2021).

The appropriate methodology to assess body composition must consider the principles of each level separately, so that the sum of each parameter of the different levels determines the total body mass. The first atomic level considers the amount of hydrogen, carbon, oxygen and other atoms; The second molecular level encompasses FM and fat-free mass that incorporates total body water and bone mineral density; The third cellular level includes fat cells, intracellular and extracellular water, and body cell mass; The fourth tissue level examines the amount of fat and lean tissue and SMM; The fifth level of the body in its entirety includes the sum of the mass of the different segments, such as the head, trunk and limbs (Silva 2019, Campa et al. 2021).

Taking as a starting point the gold standard for the assessment of body composition, with reference to FM the 4-compartment method or the air displacement plethysmograph is catalogued. Something that, due to the financial aspect, is practically impractical from a clinical point of view. When analysing the assessment of bone mineral density, the reference is dual energy X-ray absorptiometry, where the unfeasible budgetary context usually remains. And for SMM the standard method is magnetic resonance imaging (Campa et al. 2021). That is, the reference methods or gold standards are not those that, from a practical point of view, are the easiest to use (Campa et al. 2021, Kasper et al. 2021).

Conversely, the bioelectrical impedance analysis (BIA) method is commonly used for body composition assessment in clinical practice and research. In fact, BIA is a simple, non-invasive and low-cost device used to estimate FM and SMM by measuring the electrical impedance (combination of reactance and resistance factors) of a human body (Achamrah et al. 2018, Jung et al. 2021). The FM percentage is calculated by inserting the body impedance value into a predetermined regression equation based on previous population data – being then classified as a doubly indirect method. The parameters usually entered into the equation are age, sex, height, weight, and impedance (Jung et al. 2021).

On the other hand, in addition to measuring height and weight, the most standardized anthropometric variables currently are muscle girths and skinfolds. This method is a low-cost technique with accessible equipment (anthropometric tape measure and calibrated adipometer), allowing the assessment to be carried out in different locations and conditions in the field, making it a popular method for estimating FM in the case of skinfolds and SMM in the case of muscular girths (Kasper et al. 2021). To measure the skinfolds, it is necessary to highlight the existing folds in the skin to use the adipometer to measure the thickness of the folds (Wagner and Teramoto 2020).

When using skinfolds, it is common to prefer that the skinfolds sum be reported as a percentage of FM. Thus, adding another layer of complexity as it turns the already indirect method into a doubly indirect method. Conversion to FM in percentage should be discouraged presenting instead the skinfolds sum, a more accurate and reliable result of the assessment of body composition (Kasper et al. 2021). The assessment of skinfolds is shown to be the practical method least affected by daily activities, meal intake and changes in hydration status (Wagner and Teramoto 2020, Kasper et al. 2021,).

The aims of the present investigation were the analysis of the relationship between the most used methods in clinical practice. In this case, the values obtained by BIA, such as SMM, FM and waist-hip ratio (WHR), and by anthropometry, namely muscle girths and skinfolds, of the body composition of university athletes are compared. The analysis takes into account the existing scientific literature in the area and seeks to be another source in it.

Material and Methods

Study Design

The study is classified as an observational analytical study. Direct interventions on the sample were not manipulated, only the assessment of the individuals' body composition was performed. The sample is considered non-probabilistic. Regarding the sampling technique, it is for convenience, since the individuals were selected according to the specific inclusion criteria. A first phase took place during the month of November 2021 to January 2022 for the planning and elaboration of the research project. The second phase took place from February 2022 to June 2022 for data collection and analysis.

Participants

Study participants include football athletes from a higher education institute team, who belong to its constituent organic units. The inclusion criteria for the study were voluntary members belonging to the university team, over 18 years old. From a population of 28 football university athletes, 26 authorizations were obtained for the proposed study. Participation responses resulted in about 93% of the total population.

Body composition assessment protocol

Data collection from body composition assessments was carried out exclusively by the anthropometrist researcher with a restricted profile accredited by ISAK. In order to access the materials needed for the present investigation, a request was made to ceding the equipment of the Coimbra Health School was approved. The collections took place at a private space close to the locker rooms before the start of the scheduled weekly training sessions for the football team in February 2022.

Height was measured using a Seca703® stadiometer scale. Measurements of body composition values by BIA were obtained using the InBody230® scale. For the correct assessment, the subjects were wearing as little clothing as possible in an anthropometric position, but with their hands apart in contact with the BIA receptors, as well as their feet. The preconditions for evaluation in the BIA were sent to the athletes in a timely manner: No eating or drinking 4 hours before; No exercise 12 hours before; Urinate 30 minutes before; No alcohol consumption 48 hours before; No diuretics 7 days before (Jung et al. 2021).

The girths measurement was performed using the Cescorf® tape measure and the skinfolds measurement was performed using the GIMA27320® adipometer, both also using the anthropometric box. For anthropometry, the measurement standards used were those approved by the ISAK, which can be found in the International Standards for Anthropometric Assessment (Esparza-Ros et al. 2019).

After the evaluation, the athletes were informed of their body composition values, in particular the skinfolds sim. As a reference of values for the recommendation of the sum of the eight skinfolds, the recent work by Kasper et al. 2021 was considered, through the sums expressed for elite soccer players: The lower interval between 40-45 mm; The average range between 45-55 mm; And the upper range between 55-65mm. Although it was also reflected the difficulty of comparing values between different athletes, modalities, and competitive levels.

Study variables

In the present study, the independent variables "Age", "Height", "Weight", "Body Mass Index" were analysed, relating them with the dependent variables obtained by BIA “FM percentage”, “SMM total”, “WHR” and with the dependent variables obtained by anthropometry “Girths: Relaxed and contracted arm, waist, hip, thigh and calf”, “WHR girths”, “Skinfolds: Triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, tight and calf”, “Skinfolds sum”.

Data Analyses

The collected data were entered into a database and analysed in the IBM® SPSS® Statistics – Version 27 program. In the first instance, statistics were applied in order to describe the population under study. Considering a critical significance level of 5% for a confidence level of 95% to test the hypotheses between the variables under study and their correlations, Pearson's parametric test of linear correlation coefficient was applied. In order to define the degrees of association between the pairs of variables, the following intervals were taken into account for the positive or negative correlation coefficients (Pestana and Gageiro 2003), [0; 0.2[- Very low; [0.2; 0.39[- Low; [0.4; 0.69[- Moderate; [0.70; 0.89[- High; [0.9; 1] - Very high.

Ethical Considerations

Before the beginning of the evaluation, the participants were informed of the procedures and the informed consent for participation signed by them was collected. The data collection place was a private space and the collection respected confidentiality, privacy and all ethical principles inherent to human studies. The privacy principles were respected in all dimensions: at the time of data collection, when the athlete signed the informed consent, the document had an associated code, coinciding with the code of the document that contains the data obtained, which were stored in computer support for exclusive use with limited password access by the researchers. Subsequently, only the researchers had access to this information, who will not disclose it to third parties or use it for their own benefit.

The study protocol was approved by the Polytechnic Institute of Coimbra Ethic Committee, N.º 37_CEIPC/2022 was obtained. The free and informed consent form was adapted from the base models provided by the Ethic Committee.

Results

Descriptive statistical analysis is shown in the table below (Table 1). All study variables of the study sample were represented: From age, height, weight, Body Mass Index; BIA specific values such as SMM, MG and WHR; Up to specific anthropometric values such as girths of waist, hip, WHR, relaxed arm, contracted arm, thigh and calf and skinfolds of triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, tight, calf and sum.

The correlations between the FM percentage obtained by BIA and the individual skinfolds and the sum obtained by anthropometry are represented (Table 2; Figure 1). There were moderate positive correlations with statistical significance between the FM percentage and triceps (r=0.563; p=0.003), abdominal (r=0.674; p=<0.001), tight (r=0.455; p=0.020) and calf (r=0.620; p=0.001). There were also high positive correlations with statistical significance between the FM percentage and subscapular (r=0.719; p=<0.001), biceps (r=0.723; p=<0.001), iliac crest (r=0.739; p =<0.001), supraspinale (r=0.751; p=<0.001) and skinfolds sum (r=0.782; p=<0.001).

Taking into account the skinfolds sum as a global indicator of anthropometry to identify FM in individuals, a scatter diagram was created (Figure 2). In the figure, the axes are represented by the values of the present research, being indicated on the vertical axis (y) the value in percentage of FM analysed by BIA and being indicated on the horizontal axis (x) the value in millimetres of the skinfolds sum analysed by anthropometry. Through the elaboration of the diagram, the following linear r^2 = 0.612 was obtained, representing the correlation between the variables.

Table 1. Descriptive statistical analysis of the study sample

	N	Minimum	Maximum	Mean	Standard Deviation
Age (years)	26	18,0	27,0	21,15	2,20
Height (cm)	26	165,0	194,0	178,08	6,37
Weight (kg)	26	57,2	92,5	73,20	10,12
Body Mass Index (kg/m^2)	26	18,1	28,3	23,02	2,41
SMM (kg)	26	21,8	49,0	36,60	5,96
FM (%)	26	1,8	19,7	8,53	4,31
WHR	26	0,73	0,90	0,80	0,04
Waist girth (cm)	26	70,0	96,5	82,08	7,30
Hip girth (cm)	26	83,0	104,0	92,67	5,87
WHR girth	26	0,81	0,97	0,89	0,03
Relaxed arm girth (cm)	26	26,0	35,0	29,69	2,48
Contracted arm girth (cm)	26	27,0	37,0	31,12	2,45
Tight girth (cm)	26	44,5	58,0	52,48	3,66
Calf girth (cm)	26	28,0	41,0	37,23	2,93
Triceps skinfold (mm)	26	5,0	20,0	10,64	3,73
Subscapular skinfold (mm)	26	6,0	28,0	11,13	4,31
Biceps skinfold (mm)	26	3,0	10,0	5,06	1,97
Iliac crest skinfold (mm)	26	5,5	24,0	12,90	5,12
Supraspinale skinfold (mm)	26	5,5	23,0	11,15	4,59
Abdominal skinfold (mm)	26	8,0	26,0	16,52	5,06
Tight skinfold (mm)	26	6,0	30,0	15,67	6,38
Calf skinfold (mm)	26	4,5	22,0	9,80	4,40
Skinfolds sum (mm)	26	50,5	173,0	92,87	29,26

Table 2. Correlation (Pearson test) between BIA FM and individual skinfolds and skinfolds sum. Caption: **. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

		FM (%)
Triceps skinfold (mm)	Pearson Correlation	0,563**
	Sig. (2-tailed)	0,003
Subscapular skinfold (mm)	Pearson Correlation	0,719**
	Sig. (2-tailed)	<0,001
Biceps skinfold (mm)	Pearson Correlation	0,723**
	Sig. (2-tailed)	<0,001
Iliac crest skinfold (mm)	Pearson Correlation	0,739**
	Sig. (2-tailed)	<0,001
Supraspinale skinfold (mm)	Pearson Correlation	0,751**
	Sig. (2-tailed)	<0,001
Abdominal skinfold (mm)	Pearson Correlation	0,674**
	Sig. (2-tailed)	<0,001
Tight skinfold (mm)	Pearson Correlation	0,455*
	Sig. (2-tailed)	0,020
Calf skinfold (mm)	Pearson Correlation	0,620**
	Sig. (2-tailed)	0,001
Skinfolds sum (mm)	Pearson Correlation	0,782**
	Sig. (2-tailed)	<0,001

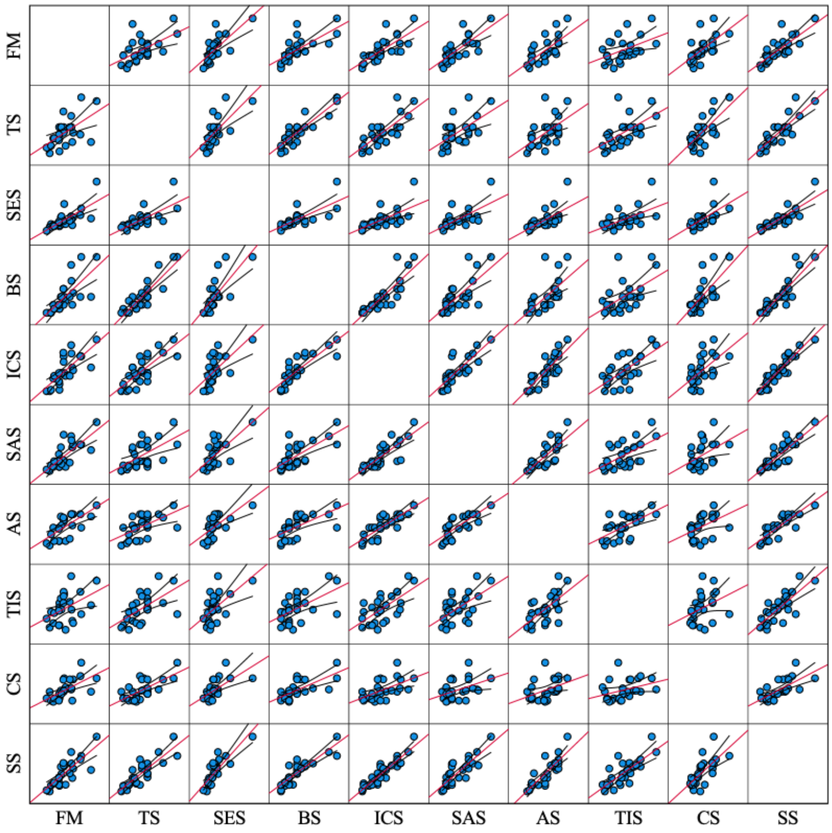

Figure 1. Scatter diagrams between BIA FM and individual skinfolds and skinfolds sum. Caption: FM – BIA FM; TS – Triceps skinfold; SES – Subscapular skinfold; BS – Bicep skinfold; ICS – Iliac crest skinfold; SAS – Supraspinal skinfold; AS – Abdominal skinfold; TIS – Tight skinfold; CS – Calf skinfold; SS – Skinfolds sum.

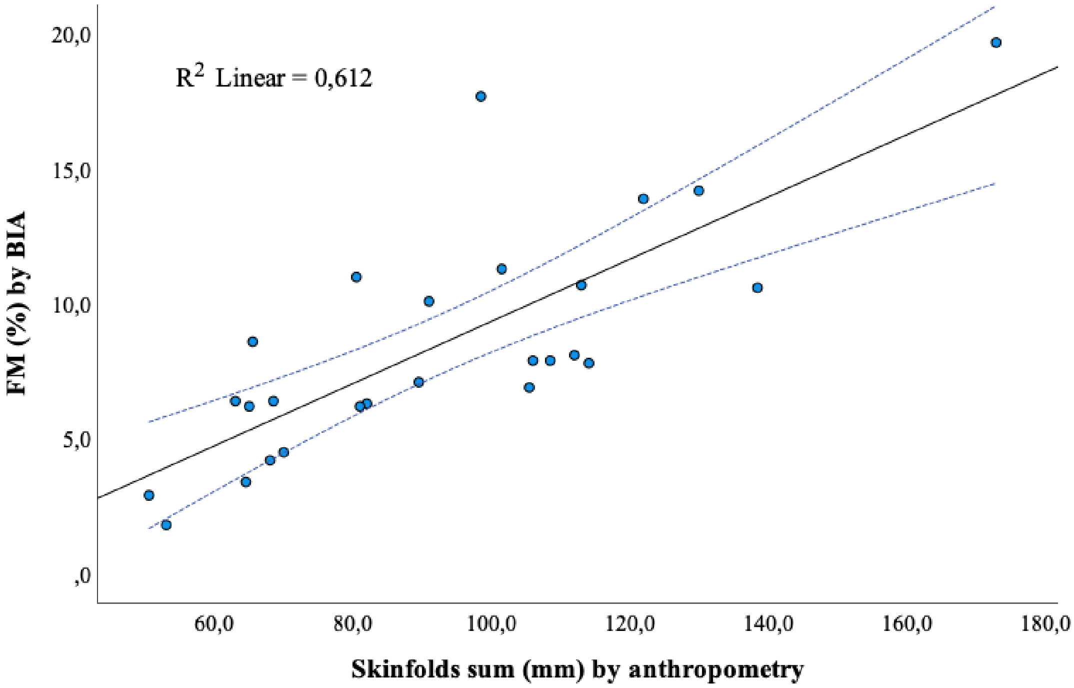

Figure 2. Scatter diagram between the FM of the BIA and the skinfolds sum of the anthropometry

Below are the correlations between the SMM analysed by BIA and the muscle girths analysed by anthropometry (Table 3; Figure 3). There was a moderate positive correlation with statistical significance between the absolute value of SMM and thigh girth (r=0.626; p=0.001). There were also high positive correlations with statistical significance between the absolute value of SMM and the girths of the relaxed arm (r=0.710; p=<0.001), contracted arm (r=0.754; p=<0.001) and calf (r= 0.727; p=<0.001).

Table 3. Correlation (Pearson test) between the SMM of the BIA and the girths of relaxed and contracted arm, thigh and calf. Caption: **. Correlation is significant at the 0.01 level (2-tailed).

		SMM (kg)
Relaxed arm girth (cm)	Pearson Correlation	0,710**
	Sig. (2-tailed)	<0,001
Contracted arm girth (cm)	Pearson Correlation	0,754**
	Sig. (2-tailed)	<0,001
Tight girth (cm)	Pearson Correlation	0,626**
	Sig. (2-tailed)	0,001
Calf girth (cm)	Pearson Correlation	0,727**
	Sig. (2-tailed)	<0,001

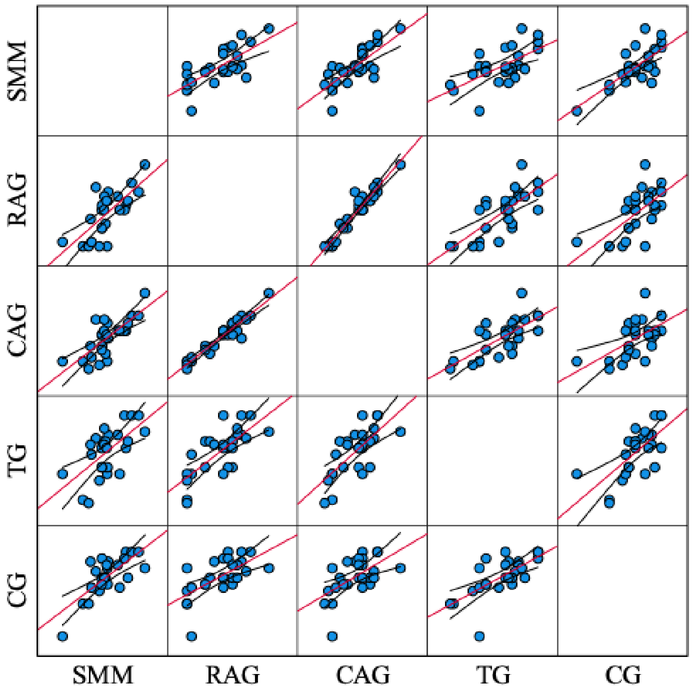

Figure 3. Scatter diagrams between the SMM BIA and the girths of relaxed and contracted arm, thigh and calf. Caption: SMM – BIA SMM; RAG – Relaxed arm girth; CAG – Contracted arm girth; TG – Thigh girth; CG – Calf girth.

Table 4. Correlation (Pearson test) between WHR of the BIA and waist girth, hip girth and WHR girths. Caption: **. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

		WHR
Waist girth (cm)	Pearson Correlation	0,490*
	Sig. (2-tailed)	0,011
Hip girth (cm)	Pearson Correlation	0,426*
	Sig. (2-tailed)	0,030
WHR girths	Pearson Correlation	0,414*
	Sig. (2-tailed)	0,036

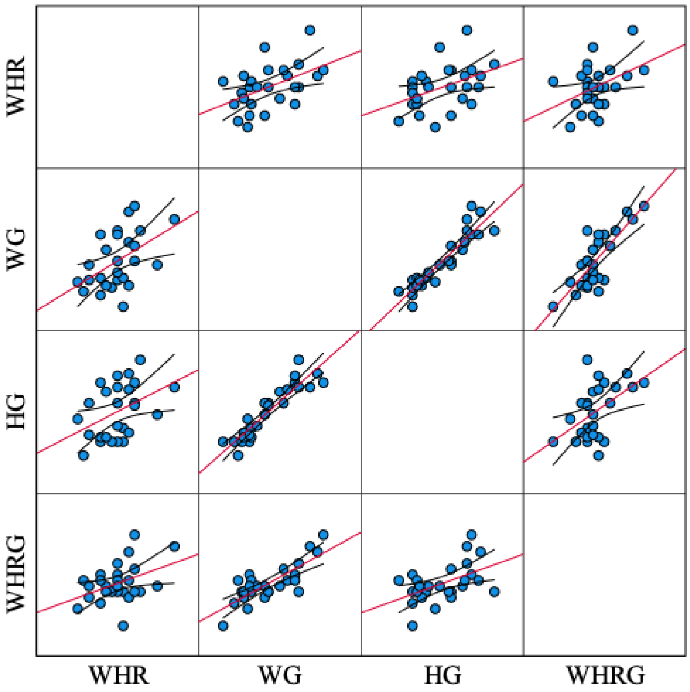

Figure 4. Scatter diagrams between WHR BIA and waist girth, hip girth and WHR girths. Caption: WHR – BIA WHR; WG – Waist Girth; HG – Hip girth; WHRG – WHR girths.

Discussion

The aims of the present research were the analysis of the relationship between the most used methods in clinical practice. In this case, the values obtained by BIA and by anthropometry of body composition of university athletes are compared. In the scientific literature, the different methodologies are correlated with each other and with reference methods for the evaluation of FM and SMM in athletes (López-Taylor et al. 2018, Núñez et al. 2020, Canda 2021, Dimitrijevic et al. 2021,). However, other studies do not demonstrate the referred correlation due to the underestimation of the FM percentage calculated by the BIA when the methodologies were compared with the dual energy X-ray absorptiometry (Lee et al. 2017, Suarez- Arrones et al. 2018, Munguía-Izquierdo et al. 2019, Nuñez et al. 2019, Martinez-Ferran et al. 2022).

According to Suarez-Arrones et al. 2018, FM percentage values range from 5% to 19% in male athletes depending on the sport, position when applicable, and also on the methodology used to assess FM. Additionally, it is also noticeable that the studies refer to specific methods and that equations are developed for specific populations and certain nationalities (similar in anthropological terms and their characteristics). Exposure to numerous methods for evaluating FM increases the chances of selecting inappropriate anthropometric methods for athletes, which can lead to significant mismanagement errors (Dimitrijevic et al. 2021).

In the present study, the comparison between the FM percentage assessed by BIA revealed a high positive correlation with the skinfolds sum (r=0.782; p=<0.001), as well as other correlations with individual skinfolds. However, most studies in the area take into account not the skinfolds sum, but equations to determine the FM percentage through skinfolds (Dimitrijevic et al. 2021, López-Taylor et al. 2018, Suarez-Arrones et al. 2018, Munguía-Izquierdo et al. 2019, Martinez-Ferran et al. 2022). For football, one of the modalities with more scientific studies, there is no consensus on the most accurate equation for the FM evaluation (Martinez-Ferran et al. 2022).

In the case of muscle girths, the moderate positive correlations identified with the SMM evaluated by the BIA can be explained, according to Munguía-Izquierdo et al. 2019 due to the players' girths being influenced by the muscle cross-sectional area of low adipose tissue of the main muscle groups. Thus, it is confirmed by the correlations from the girths of the relaxed arm (r=0.710; p=<0.001) and contracted arm (r=0.754; p=<0.001), thigh (r=0.626; p=0.001), to the calf (r=0.727; p=<0.001) with absolute SMM by BIA. However, the situation is similar to that of FM since there are no standardized cohort points for SMM measurements in different populations (Bahat et al. 2019, Villada-Gómez et al. 2021).

The interpretation of data evaluated by the BIA begins to be dubious due to the fact that there are studies that do not demonstrate correlations of results between different BIA devices (Kim et al. 2022, Lee et al. 2017). For example, the predictive equations of the InBody230® scale for evaluating FM and SMM are not publicly available and cannot be manipulated by users. In the same way as the WHR obtained by the BIA in the present study, which showed significant lower correlations compared with the other parameters with the WHR of anthropometry, making it impossible to discuss this part of the results. Therefore, it would be interesting to have the ability to manipulate the predefined equations to potentially increase the accuracy of results within specific populations (Suarez-Arrones et al. 2018).

BIA is a widely used method for assessing body composition, although it has limited accuracy for estimating FM and SMM (Martinez-Ferran et al., 2022). The accuracy of the BIA is easily affected by potential physiological oscillations of the human body influenced by changes in body fluids and therefore subjects are required to be hydrated (Canda 2021, Dimitrijevic et al. 2021). Thus, athletes are required to deal with a long and strict preparation protocol (which begins 48 hours before) and researchers are required to trust athletes to fully comply with the protocol prior to the BIA assessment (Canda, 2021, Dimitrijevic et al. 2021, Jung et al. 2021).

In addition to the very strict protocol for its correct assessment, the equations developed for BIA are calculated for a specific population and are only validated for similar individuals. Caution is required when applying to a population different from the original sample in order to avoid incorrect results and misinterpretations (Achamrah et al. 2018, Campa et al. 2021). Research that adjusts the variables and subsequently the values of predefined equations could help reduce calculation errors (Suarez-Arrones et al. 2018). The use of BIA to estimate the FM percentage in elite athletes does not seem to be sufficiently accurate (Martinez-Ferran et al. 2022).

In contrast, anthropometry is based on anatomical measurements that require a much simpler preparation for assessing body composition in athletes (Dimitrijevic et al. 2021, Esparza-Ros et al. 2019). As mentioned earlier, anthropometry also has practical advantages in the field. For example, anthropometric equipment takes up less space than BIA devices, weighs less, and has no electrical components, running significantly less risk of damage during transport (Dimitrijevic et al. 2021, Jung et al. 2021). There may be clear advantages of anthropometry in relation to BIA when the assessment is performed in competition contexts or moments before training, as in the case of the present study.

Thus, anthropometry represents a non-invasive, financially cost-effective and relatively quick tool to accurately estimate FM in the university athletic population. The skinfolds sum seems to be the best alternative when time and budget are both limited (Kasper et al. 2021, Suarez-Arrones et al. 2018). The authors of several studies consider that the anthropometry technique is an accepted method as long as it is performed by an accredited anthropometrist and the standardized guidelines are precisely followed (Canda 2021; Martinez-Ferran et al. 2022). It is important to point out that the ISAK guidelines were strictly followed in the present study in order to reduce the technical error between measurements.

In similar studies, a comparison with dual energy X-ray absorptiometry was added to the methods by BIA and by anthropometry (Lee et al. 2017, Achamrah et al., 2018, López-Taylor et al. 2018, Suarez-Arrones et al. 2018, Munguía-Izquierdo et al. 2019, Nunez et al. 2019, Núñez et al. 2020, Martinez-Ferran et al. 2022). Although it is the gold standard for the assessment of bone mineral density, it should be noted that it cannot be considered for the assessment of SMM due to estimates and inaccuracies in its calculation, as Canda 2021 refers in her investigation. It should also be noted that in each study different devices of different brands and different equations were used in the case of anthropometry to calculate the percentage of FM and SMM. As discussed in the study by Martinez-Ferran et al. 2022, it is therefore difficult to compare the results of scientific articles in the specific area of body composition assessment.

In the same theme of comparison between data obtained by anthropometric equations or different methods that do not seem appropriate, careful must be taken when feedback to athletes is provided in percentages, valuing whenever possible absolute values such as, for example, the skinfolds sum (Suarez-Arrones et al. 2018, Campa et al. 2021, Kasper et al. 2021,). Anthropometry and BIA are considered practical methods for assessing body composition in athletes (Martinez-Ferran et al. 2022). Anthropometric techniques and BIA can be considered to have a high degree of agreement, which is valid for epidemiological research, although not fully convertible, taking into account the inter-individual variability and errors that can also be made in comparative studies (Canda 2021). Future longitudinal studies are needed to determine the most appropriate method to assess possible changes in FM and SMM over time (Suarez-Arrones et al. 2018, Munguía-Izquierdo et al. 2019, Martinez-Ferran et al. 2022).

However, the paradox still exists regarding predictive equations, as initially mentioned in the introduction, to determine the basal metabolic rate and later the total energy requirements. Even with successful education of athletes to read their own body composition in absolute values, predictive equations are still needed to transpose FM and SMM values to calculate their energy requirements (Jagim et al. 2018, Hannon et al. 2020,). In the case of university athletes, the underestimation of these predictive equations is commonly seen (Jagim et al. 2018). Thus, the knowledge of professionals who use them continues to be necessary in order to carefully consider the specific population and the methodologies used to evaluate FM and SMM (Hannon et al. 2020).

Conclusion

One of the main limitations of the present study was the lack of a reference method to validate the FM and SMM values and subsequently determine the correlation with the BIA method and anthropometry. Without a reference method, the results of this research can only demonstrate that the methods studied are correlated with each other. It would thus be very useful and interesting to repeat the same type of study, but with the addition of a reference method for assessing body composition, such as magnetic resonance imaging, air displacement plethysmograph or dual energy X-ray absorptiometry.

On the other hand, another limitation of the present investigation was the sample of university students. In addition to being a small number of individuals, the variability of the sample is very wide in terms of the skinfolds sum. Although some of the athletes were within the reference values, most were excessively above the references. The sample consisted entirely of male athletes, mostly Caucasian, not taking into account the variability between genders and ethnicities. The study focused on university athletes exclusively in the football team, although it is underlined the multi-sports practised for most athletes.

In summary, the study examined the correlation between the values obtained for FM and SMM by BIA and by anthropometry verified by skinfolds and muscle girths in the male population of university athletes. Additionally, it is intended to make it easier for interested sports professionals to select practical methods for assessing the body composition of their athletes, while eliminating the risk of selecting inappropriate methods. Thus, the possibility of replacing or complementing the BIA by a more accessible and viable anthropometric method, such as the sum of skinfolds, is highlighted

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Abbreviation: BIA: Bioelectrical impedance analysis; FM: Fat mass; SMM: Skeletal muscle mass; WHR: Waist-hip ratio.

Conflicts of Interest

The authors do not have any source of funding to declare.

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