How to cite: Ferreira CP, Brito FM, Silvino VO, Silva LLR, Costa CM, Santos MAP. Comparison between direct measurement of waist-to-hip ratio and indirect estimation using the InBody S10 device. Rev Bras Fisiol Exerc. 2022;21(5):295-302. doi: 10.33233/rbfex.v21i5.5403

RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Original article

Comparison between direct measurement of waist-to-hip ratio and indirect estimation using the InBody S10 device

Comparação entre a mensuração direta da relação cintura quadril e a estimação indireta pelo dispositivo InBody S10

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ABSTRACT

Introduction: The waist-hip ratio (WHR), calculated with the division between waist and hip measurements, is considered an important tool for checking the risk of developing cardiovascular diseases. The measuring tape, regarded as the gold standard tool for assessing WHR, is accessible and easy to use. However, there are other tools capable of estimating WHR values, such as the InBody S10 bioimpedance analyzer. This study aimed to compare the WHR value estimated by the InBody S10 device with the values measured with the measuring tape. **Methods:** 98 healthy young subjects (23.9 ± 5.77 years, 68.9 ± 12.67 kg, 1.69 ± 0.1 m) had their waist and hip measurements directly assed with a measuring tape and indirectly estimated by the InBody S10 device. The intraclass correlation coefficient (ICC) and standard error of measurements (SEM) were used to verify reliability. The Pearson correlation coefficient and Bland-Altman tests were applied to compare the evaluation methods. Statistical significance was set at $p < 0.05$. **Results:** The InBody S10 device showed low SEM levels (0.03). However, the InBody S10 significantly overestimated the WHR values ($p < 0.05$). Furthermore, the methods showed a low intra-class correlation between repetitions (ICC = 0.24) and a low correlation between them (r= 0.26). **Conclusion:** The InBody S10 device did not display valid values for estimating the waist-hip ratio. Therefore, it may not be accurate enough for this estimation in healthy young people.

Keywords: heart disease risk factors; body composition; waist-hip ratio.

RESUMO

Introdução: A relação cintura-quadril (RCQ), calculada a partir da divisão entre a medida da cintura e do quadril, é considerada uma importante ferramenta de verificação de risco de desenvolvimento de doenças cardiovasculares. A fita métrica, ferramenta padrão ouro para a avaliação da RCQ, é acessível e de fácil utilização. Porém, existem outras ferramentas capazes de estimar os valores da RCQ, tais como o analisador de bioimpedância InBody S10. Este estudo buscou comparar o valor da RCQ estimado pelo dispositivo InBody S10 com os valores mensurados a partir da fita métrica. **Métodos:** 98 jovens saudáveis (23,9 ± 5,77 anos, 68,9 ± 12,67 kg, 1,69 ± 0,1 m) tiveram as medidas da cintura e do quadril diretamente avaliadas a partir do uso da fita métrica e indiretamente estimados pelo dispositivo InBody S10. O coeficiente de correlação intraclasse (CIC) e o erro padrão das medidas (EPM) foram utilizados para verificar a confiabilidade. Foi aplicado o teste coeficiente de correlação de Pearson e de Bland-Altman para comparar os métodos de avaliação. A significância estatística foi estabelecida em $p < 0{,}05$. **Resultados:** O dispositivo InBody S10 apresentou baixos níveis de EPM (0,03). Porém, o InBody S10 superestimou significativamente os valores da RCQ ($p < 0{,}05$). Além disso, os métodos apresentaram uma correlação intraclasse baixa entre as repetições (CIC = 0,24) e uma correlação baixa entre si (r = 0,26). **Conclusão:** O dispositivo InBody S10 não exibiu valores válidos quanto à estimação da relação cintura-quadril. Portanto, ele pode não ser acurado o suficiente para essa estimação em jovens saudáveis.

Palavras-chave: fatores de risco de doenças cardíacas; composição corporal; relação cintura-quadril.

Received: September 12, 2022; Accepted: November 11, 2022.

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Introduction

Anthropometric measurements are quantitative assessments of body dimensions, such as height, body mass, and waist and hip circumferences [1]. The standard anthropometric measurement tool used by the World Health Organization (WHO) is the Body Mass Index (BMI) as an indicator of nutritional status and health risks. Waist-to-hip ratio (WHR) is regarded as an alternative to BMI as an anthropometric measurement [2].

The WHR is calculated by dividing the waist perimeter measurements for the hip perimeter [3]. This measure can be used to indirectly verify the health status of individuals, as well as to predict the risk of cardiovascular diseases [4, 5].

A high WHR value is regarded as an indicator of increased risk of dyslipidemia, hypertension, diabetes mellitus [6], as well as the appearance of colorectal adenomas, which may progress to cancer [7]. In addition, WHR can be used to infer the central distribution of body fat [8,9] and visceral fat indices, which, when elevated, can result in insulin resistance, metabolic syndromes, and cardiovascular problems [10,11].

Bioimpedance body composition analysis (BIA) is a fast, non-invasive, relatively accurate, and painless method to obtain body composition data from different electrical currents, providing information such as lean mass, fat mass, and fat percentage [9,12]. The Inbody S10 BIA device (InBody Ltd, Seoul, South Korea) uses segmental impedance and reactance at various frequencies to determine several body composition variables, including total body water, extracellular water, phase angle, fat percentage, and WHR values. This instrument was validated for estimating body fat in patients with renal failure after a hemodialysis session [13]. However, there are still no studies verifying its validation regarding the estimation of the WHR. Once its validation is verified, the InBody S10 device can be an alternative for estimating WHR for professionals and scientists, despite the practicality and accessibility of the measuring tape.

This study aimed to verify the validity of the bioimpedance analyzer InBody S10 in estimating the WHR in healthy subjects.

Methods

The present study has a cross-sectional and observational design. Ninety-eight individuals of both sexes (23.9 ± 5.77 years, 68.9 ± 12.67 kg, 1.69 ± 0.1 m) were included. The sample was recruited by homogenized convenience. Regarding the inclusion criteria, we selected: (1) individuals aged between 18 and 50 years; (2) of both sexes and (3) who signed the consent form. As exclusion criteria, the following were not eligible: (1) individuals under the age of 18; (2) pregnant women, and (3) pacemaker wearers. The participation of individuals was voluntary and proceeded after signing the consent form. This study was approved by the Research Ethics Committee of the Federal University of Piauí, Teresina, Brazil, under protocol number 3,131,097 and was conducted in accordance with the guidelines by the Declaration of Helsinki. Additional characteristics of the participants, including age, height, body mass and BMI separated by sex are shown in Table I.

Table I - Characteristics of the participants

	Female (N = 43)	Male (N = 55)
Age (years)*	24.47 ± 6.57	23.44 ± 5.08
Height (m)*	1.60 ± 0.06	1.76 ± 0.06
Body mass (kg)*	60.1 ± 9.64	75.8 ± 10.2
BMI (kg/m²)*	23.35 ± 3.48	24.54 ± 3.07

*Mean ± Standard Deviation

Data collection instruments

An anamnesis form was applied for the participants to verify age, body mass, height, physical integrity, and healthy state at the beginning of the experiment. To determine the WHR measurements, it was used the indirect method via BIA with the InBody S10 device (*InBody Ltd, Seoul, South Korea*) and the direct method, with the tape measure (Essencial RMC, Brazil).

Procedures

Participants underwent anthropometric tests (body mass and height). Afterwards, the WHR measurements were calculated via BIA and using the tape measure. The direct measurement of WHR was performed based on waist perimeter (WP) and hip perimeter (HP). The subject was positioned in the orthostatic position with relaxed abdomen and upper limbs at the side of the body, feet together and with normal breathing. The WP was measured at the midpoint between the lower rib and the upper border of the iliac crest. The HP was considered the largest diameter of the trochanteric region, measured laterally. Both evaluations were conducted twice, then an average was performed. For measurements that differed by more than 3 cm, a third measurement was performed [14,15].

BIA was performed with the InBody S10 device (*InBody Ltd, Seoul, South Korea*). The subjects were positioned in dorsal decubitus, with upper limbs extended along the body and lower limbs in extension, keeping a distance of 15 to 20 cm between them. The electrodes were placed on the hands (middle fingers and thumbs) and on the legs (ankles). The evaluations were performed by a trained Physical Education professional in an air-conditioned environment, according to the guidelines proposed by the user's manual. Participants were previously instructed that, at the time of the test, they were not menstruating, had not performed physical activity, did not wear a pacemaker, did not use accessories or metallic clothing, steel, or any conductive materials, to avoid altered results [16].

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Statistical analysis

Shapiro-Wilk and Levene tests were conducted to verify the normality and homogeneity of data variance, respectively. To verify the reliability of the data, the intraclass correlation coefficient (ICC) and the standard error of measurements (SEM) were performed. Pearson's correlation coefficient was used to assess how strongly the values are correlated. The magnitude of the correlation adopted was: "very low" (0.00 - 0.25), "low" (0.26 - 0.49), "moderate" (0.50 - 0.69), "strong" (0.70 - 0.89) and "very strong" (0.90 - 1.00) [17]. The agreement between each pair of methods was evaluated using the Bland-Altman graphical analysis [18]. The significance level was set at $p < 0.05$ for all analyses. For the statistical analysis, the software SPSS version 20.0 (*SPSS Inc., Chicago, IL, USA*) was used.

Results

The paired t-test showed an overestimation of the values obtained by the InBody S10 device when compared to the measuring tape (0.87 vs. 0.78, respectively). The ICC showed a small correlation between repetitions for both methods (ICC = 0.24; 95% CI = -0.134-0.500; p=0.006). However, the InBody S10 device demonstrated low levels of SEM (0.03).

Table II - Mean ± Standard Deviation of the WHR determined by the methods and the absolute and relative differences in relation to the gold standard method (BIA)

Methods	WHR	Absolute difference	Relative difference (%)
	0.87 ± 0.06	-	-
Measuring tape	0.79 ± 0.06	0.08 ± 0.08	10.12

WHR = Waist-to-hip ratio; BIA: Bioimpedance analysis

There was a low correlation between the WHR values obtained by the InBody S10 bioimpedance analyzer and measuring tape ($r = 0.26$; $R^2 = 0.07$; $p = 0.01$) (Figure 1).

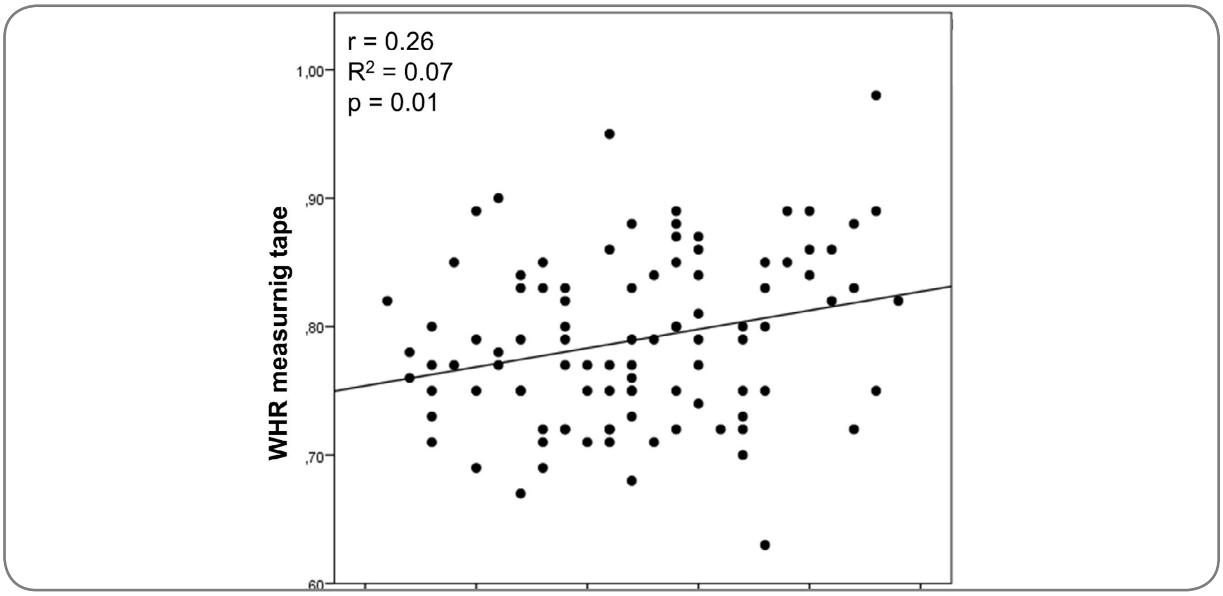

Figure 1 - Correlation between the WHR values estimated by the measuring tape and the InBody S10 bioimpedance analyzer

The degree of agreement between the BIA and the measuring tape was assessed using the Bland-Altman test, within a 95% confidence interval, as shown in Figure 2. Based on this analysis, it can be seen that the difference between the instruments is found within the limits of agreement.

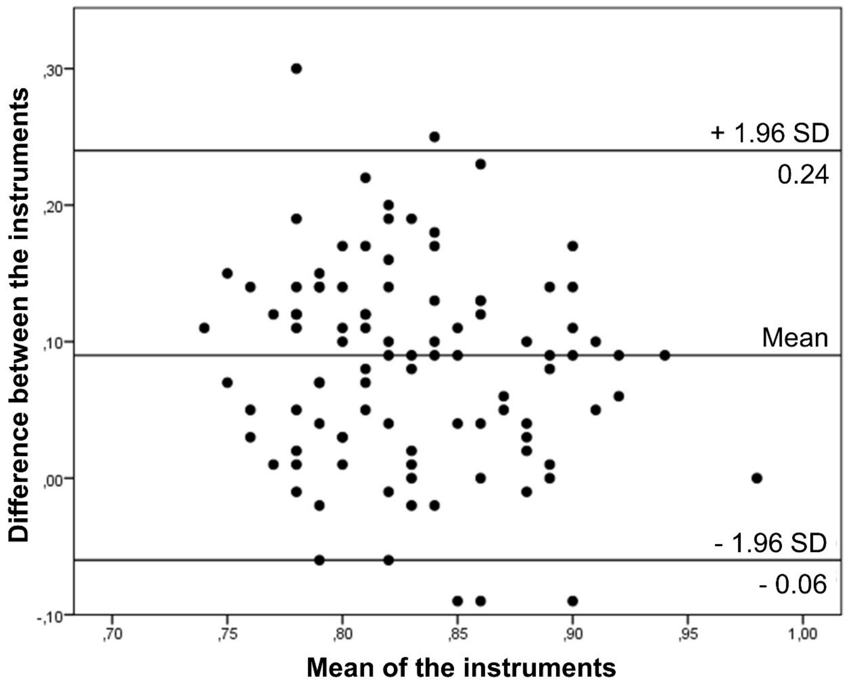

Figure 2 - Analysis of the Bland-Altman scatter plot of the difference and mean of measurements recorded by the InBody S10 instruments and the measuring tape

Discussion

The present study compared the estimates of central distribution of body fat through WHR, obtained by a measuring tape and the InBody S10 bioimpedance analyzer. The indirect method of estimating the WHR showed a statistically significant difference when compared to the gold standard method. When the relationship between the methods was evaluated, weak correlations were found between the measuring tape and the InBody S10 device through the ICC test that was used to assess the agreement between the results.

The WHR assessment can be of great value in the practice of healthcare professionals, since its quantification allows the assessment of the risk of cardiovascular diseases [5,19], prediction of the risk of type 2 diabetes [20], contributing to an early diagnosis, which may help in the treatment of these possible complications [21].

Previous studies aimed to evaluate the body composition results obtained using the InBody device, especially the InBody 720 model [22], analyzing the accuracy and reliability of the device for several purposes. According to Ling *et al.*, BIA is considered a simple and non-invasive device to assess body composition when compared to dual-energy X-ray absorptiometry (DXA). Through BIA, it is possible to analyze segmental tissue and lean mass [23,24] of healthy subjects, of patients on hemodialysis [13,25], of patients undergoing treatment with peritoneal dialysis [26], and children at 6 years of age or older [27, 28].

A study comparing the results of visceral fat obtained by BIA with the measurement performed through computed tomography demonstrates that the results of BIA correlated significantly with the other method, suggesting that BIA can be used as a more convenient alternative to perform this measurement [29]. Other studies, analyzing the distribution of body water measured by BIA in comparison with the deuterium oxide dilution method showed similarity between the results obtained between the two methods [30,31].

Analyzing the results of body fat percentage in 3 different BIA devices (SF--BIA4: single frequency with four tactile electrodes; SF-BIA8: single frequency with eight tactile electrodes; and MF-BIA8: multifrequency with eight tactile electrodes) and comparing with reference values by DXA and hydrostatic weighing (HW), it was found that the MF-BIA had the highest correspondence with the references and the lowest estimation error compared to the other BIA devices. Furthermore, it was found that the BIA analyses showed a tendency to overestimate the percentage in obese individuals and underestimate it in athletes [32].

In a study comparing the percentage of fat measured by BIA with another method considered the gold standard (DXA), they had findings similar to ours, where the authors found in their results a low correlation ($r = 0.30$) between the methods, concluding that bioimpedance underestimates the percentage of body fat [33].

The literature indicates that BIA has been widely used to assess body composition [34,35]. However, so far, this is the first study aiming to assess the reliability of the WHR estimation made by the InBody S10 system in comparison with the assessment performed with the measuring tape.

The results of the study indicate that the Inbody S10 system significantly overestimates the WHR data when compared to the measuring tape. Therefore, further research is suggested, including a larger and broader sample among university students, that is, including a greater number of underweight and obese individuals, so that the results found can be generalized to a young and relatively healthy public.

Conclusion

The results of the present study show that the WHR values assessed with the measuring tape and the values estimated by the InBody S10 device differed significantly from each other. The InBody S10 overestimated the WHR values, in addition to presenting a weak correlation when compared to the gold standard. Therefore, it is suggested that health professionals use the measuring tape as a tool to measure the waist-to-hip ratio in healthy young people.

Conflicts of interest
The authors declare no conflict of interest.

Funding source
This research was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES, Brazil) and *Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão* (FAPEMA).

Authors' contributions
Conception and design of the research: Ferreira CP, Brito FM, Silvino VO; **Data collection:** Ferreira CP, Brito FM, Silvino VO, Silva LLR, Costa C; **Data analysis and interpretation:** Ferreira CP, Silvino VO; **Statistical analysis:** Ferreira CP, Silvino VO; **Study coordination:** Santos MAP; **Writing of the manuscript:** Ferreira CP, Brito FM, Silvino VO; **Critical review of the manuscript for important intellectual content:** Ferreira CP, Silvino VO.

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