Original Article

Métodos de avaliação antropométrica e bioimpedância: um estudo correlacional em trabalhadores da indústria

Anthropometric and bioimpedance evaluation methods: a correlational study in industrial workers

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Submitted: 09/01/2016

Accepted: 09/16/2016

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RESUMO

Justificativa e Objetivos: A avaliação do estado nutricional através da antropometria e bioimpedância elétrica (Bia) surge como uma ferramenta promissora de custo mais acessível. Este estudo verificou a correlação entre dois métodos de avaliação corporal (avaliação antropométrica e da composição corporal e área de gordura visceral por Bia) em trabalhadores da indústria. **Métodos:** Trata-se de um estudo transversal, de caráter descritivo e correlacional, com 22 trabalhadores industriais, do município de Santa Cruz do Sul-RS. Para a avaliação da composição corporal foram aferidas variáveis antropométricas: Índice de Massa Corporal (IMC), Circunferência da Cintura (CC), Risco Cintura Quadril (RCQ), percentual de gordura corporal (%G), peso de gordura (PG), massa corporal magra (MCM) e peso ósseo (PO). Para a composição corporal, utilizou-se a Bia, através do analisador de multi-frequência octopolar (In-Body 720) para as variáveis: conteúdo mineral (CM); massa de gordura (MG); massa musculoesquelética (MME), IMC, %G, RCQ e área de gordura visceral (AGV). Na análise estatística, utilizou-se o teste de correlação de Pearson ou Spearman para avaliar a correlação entre as variáveis. **Resultados:** Dos 22 trabalhadores, 72,7% eram do sexo feminino, com idade média de 37,73 anos. Apresentaram IMC médio de 26,14kg/m², o que classifica a amostra com sobrepeso. No estudo, as avaliações feitas pelas duas técnicas apresentaram uma forte correlação entre as variáveis IMC e IMCBia, %G e %GBia, PG e MGBia, MCM e MMEBia, PO e CMBia, CC e AGVBia. **Conclusão:** Os dois métodos mostraram obter comportamento estatístico semelhante na avaliação corporal, sugerindo a possibilidade de utilização de quaisquer destas técnicas para avaliação da composição corporal.

DESCRITORES: Antropometria. Composição corporal. Impedância bioelétrica. Adiposidade central. Trabalhadores.

ABSTRACT

Background and Objectives: The assessment of nutritional status by anthropometry and bioelectrical impedance analysis (BIA), emerges as a more affordable, promising tool. This study assessed the correlation between two body evaluation methods (anthropometry and body composition and visceral fat area by BIA) in industrial workers. **Methods:** This is a cross-sectional, descriptive, and correlational study, with 22 industrial workers from the city of Santa Cruz do Sul-RS. Anthropometric variables were measured for body composition assessment: body mass index (BMI), waist circumference (WC), Waist-Hip ratio (WHR), body fat percentage (F%), fat weight (FW); lean body mass (LBM); bone weight (BW). BIA was used for body composition assessment with an octopolar multi-frequency analyzer (In-Body 720) for the variables: mineral content (MC); fat mass (FM); musculoskeletal mass (MSM); BMI; %F; WHR and visceral fat area (VFA). The statistical analysis used Pearson's or Spearman's correlation test to evaluate the correlation between variables. **Results:** Of the 22 workers, 72.7% were females, with a mean age of 37.73 years. They had an average BMI of 26.14kg/m², which classifies the sample as overweight. In the study, the assessments made by the two techniques showed a strong correlation between the variables: BMI and BMIBIA, %F and %FBIA, FW and FMBIA, LBM and MSMBIA, BW and MCBIA, WC and VFABIA. **Conclusion:** Both methods showed similar statistical behavior regarding body evaluation, suggesting the possibility of using either of these techniques to assess body composition.

KEYWORDS: Anthropometry. Body composition. Bioelectrical impedance. Central adiposity. Workers.

INTRODUCTION

Different aspects may affect workers' health, whether in the factory environment or in other sectors of productive activity, such as alterations in the nutritional status that have implications for health maintenance and for morbidity and mortality when associated with multiple chronic processes.[1, 2] Changes in body composition directly affect the nutritional status and, if detected and evaluated as early as possible, contribute to the reduction of risk factors due to health problems.[3]

When evaluating nutritional status, the use of dual indirect methods appears as a promising tool. For this evaluation, different methods can be used, such as hydrostatic weighing or imaging methods, dual X-ray absorptiometry (DEXA), magnetic resonance imaging and computed tomography (CT), considered to be the reference methods, more accurate and quite costly; however, these methods are high-cost, require a specialized team and a complex physical structure. On the other hand, there are methods that are easy to apply, with a more accessible cost, such as evaluation by anthropometry and Bioelectrical Impedance or Bioimpedance (BIA).[3-5]

Anthropometry is defined as the science that studies the measurements of human body shape, size and composition; due to the fact that it is easy to apply and the better accepted by the population, it is the most widely used method in clinical practice and epidemiological studies.[6-8] The use of body mass index (BMI) calculation is emphasized, which is one of the

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most used anthropometric indicators in nutritional risk identification, as well as the measurement of skinfold thickness (SFT), waist circumference (WC), waist-to-height ratio (WHtR), sagittal abdominal diameter (SAD), conicity index (CI) and waist-to-hip ratio (WHR), among others. However, these anthropometric measurements are not able to diagnose visceral fat separately from subcutaneous abdominal fat.[5,7,9]

Currently, BIA has been validated and used to estimate body composition and nutritional status of not only healthy individuals, but also in several clinical situations. It is an indirect method used to evaluate body composition, which estimates muscle mass, fat, water content, as well as visceral fat area (VFA). It is based on the principle that the flow of electric current has different rates throughout body according to its composition, with the muscle tissue showing less resistance to the electrical current than adipose tissue.[10,11]

Such assessment techniques are widely accepted as safe, fast, and reliable, capable of assessing individuals' nutritional status and body composition. In view of the above, the objective of this study was to verify the correlation between two methods of body evaluation (anthropometric and body composition evaluation and VFA by BIA in industrial workers).

METHODS

This is a cross-sectional, descriptive, and correlational study. The sample consisted of 22 industrial workers from the municipality of Santa Cruz do Sul, state of Rio Grande do Sul, Brazil, who agreed to participate in the reevaluations carried out in the study "New Approaches in Biodynamics for Diagnosis and Prevention of Obesity and Comorbidities in Workers and Schoolchildren", approved by the Committee of Ethics and Research with Human Beings under protocol number 703.934 / 14 and who signed the free and informed consent form.

Demographic variables, gender and age were selected. For the body composition assessment, anthropometric variables were measured [BMI, WC, WHR, percentage of body fat (%F), fat weight (FW); Lean body mass (LBM); Bone weight (BW)], as well as body composition variables by BIA [mineral content (MC)]; Fat mass (FM); Musculoskeletal mass (MSM); BMI; %F; WHR and VFA].

Weight and height were measured using an anthropometric scale (Welmy SA, Santa Bárbara do Oeste, Brazil). The BMI was calculated by measuring body weight (Kg), divided by height (m) squared (W/H^2), categorized according to the World Health Organization parameters.[12]

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The SFT (pectoral, tricipital, subscapular, supra-iliac, abdominal, thigh and mid-axillary) were measured using a scientific Lange® Skinfold Caliper plicometer (Beta Technology INC, Santa Cruz, CA, USA), with constant pressure of 10g / mm² on the contact surface, precision of 1mm and scale of 0-65mm, with a sensitivity of 0.1mm, with 3 repetitions. The %F was obtained through the sum of the seven SFTs, whereas body density was calculated using the Jackson and Pollock formula after Siri equation.[13] A Cardiomed inelastic measuring tape was used, with a length of 150 cm, divided in centimeters and subdivided in millimeters for WC and hip circumference (HC), to estimate the WHR, measured according to Heyward criteria.[13]

To estimate FW, the formula FW = weight x (%F/100) was used. For the percentage of LBM, the difference between weight and FW is used. The BM calculation is obtained from the equation: 3.02 (H^2 x R x F x 400) 0.712, with H^2 representing the height in squared meters, R represents the radius bi-styloid diameter and F represents the femur bi-epicondyle diameter, both expressed in centimeters .[14]

Body composition was estimated by BIA using an octopolar multi-frequency analyzer (In-Body 720; Biospace, Seoul, South Korea). The InBody 720 uses eight electrodes, two in contact with the palm (E1, E3) and the thumb (E2, E4) of each hand, and two in contact with the anterior (E5, E7) and posterior (E6, E8) surface of each foot plant. This device evaluates five segmental impedances (right arm, left arm, right leg, left leg, and trunk), measured at six different frequencies (1, 5, 50, 250, 500, and 1000 KHz).[11,15]

The contact points of the body with the electrodes were previously cleaned with an electrolytic cloth. The evaluations followed the protocol indicated by the manufacturer. participants were instructed not to consume alcohol 48 hours before the test; undergo a 12-hour fast and not perform moderate-to-high intensity exercise for 12 hours before the evaluation; not perform the test in the presence of a fever or dehydrated state; go to the bathroom before the test; wear light clothing and remove jewelry and metal objects or removable metallic dental implants and not consume coffee before the start of the tests.

The statistical analysis, using the software SPSS, version 20.0, was performed using descriptive statistics, frequency, percentage, mean and standard and correlation deviation, after first testing the data for normality and after applying Pearson’s or Spearman’s correlation tests. Correlation levels were classified according to Dancey and Reidy.[16]

RESULTS

Twenty-two workers participated in the study, of which 72.7% were females, with a mean age of 37.73 years. Regarding the anthropometric characteristics, it should be noted that

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the mean BMI was 26.14 kg/m², which classifies the sample as overweight. However, when analyzing the %F, both men and women were classified as above average, with percentages of 17.07% and 26.61%, respectively, which differs from the %F assessed by BIA, which showed an overall average of 30.11%, thus classifying subjects as having a high percentage of body fat (Table 1).

It is also observed that in the BIA variables, the subjects' VFA was below the risk values, with a mean of 83.75cm², which can also be seen in the estimated cardiovascular risk measured by the WC, showing a mean of 79.84 cm, indicating absence of risk, or classified as adequate.

Table 1 – Overall characterization and body composition of the sample by anthropometric and bioimpedance variables.

Variables	Gender		Overall
	Female	Male	
	16 (72.7%)	6 (27.3%)	22 (100%)
Age (years)	37.25 ±6.35	39.00 ±3.40	37.73 ±5.68
Anthropometry			
BMI (kg/m²)	26.37 ±5.77	25.52 ±2.00	26.14 ±4.98
WC (cm)	78.08 ±11.86	84.5 ±6.45	79.84 ±10.91
WHR	0.77 ±0.06	0.86 ±0.03	0.80 ±0.07
%F	26.61 ±6.13	17.07 ±4.25	23.99 ±7.09
FW (kg)	17.42 ±7.86	13.08 ±4.30	16.24 ±7.24
LBM (kg)	45.61 ±5.61	62.81 ±10.45	50.30 ±10.49
BW (kg)	8.26 ±0.83	12.07 ±3.02	9.30 ±2.38
Bioimpedance			
MC (kg)	2.78 ±0.30	4.00 ±0.86	3.11 ±0.74
FM (kg)	22.20 ±11.46	15.98 ±4.41	20.50 ±10.32
MSM (kg)	22.49 ±2.41	33.82 ±6.41	25.58 ±6.37
BMI (kg/m²)	26.29 ±6.02	25.45 ±1.98	26.06 ±5.19
%F	33.50 ±10.56	21.07 ±4.45	30.11 ±10.79
WHR	0.95 ±0.06	0.92 ±0.05	0.94 ±0.06
VFA (cm^2)	88.29 ±38.42	71.63 ±21.83	83.75 ±35.01

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BMI: body mass index; WC: waist circumference; WHR: waist-to-hip-ratio; %F: percentage of fat; FW: fat weight; LBM: lean body mass; BW: bone weight; MC: mineral content; FM: fat mass; MSM: musculoskeletal mass; VFA: visceral fat area.

When correlating body composition variables estimated by anthropometry with those estimated by BIA (Table 2), it was observed that the variables BMI versus BMIBia, %F vs. %FBia, FW vs. FMBia, LBM vs. MSMBia, BW vs. MCBia and WC vs. VFABia showed a strong correlation with a statistically significant difference, demonstrating that the assessments obtained through the different techniques have a similar behavior. That indicates the possibility of using either of these techniques to evaluate the body composition in the present group.

Table 2 - Correlation between body composition by anthropometry and by bioimpedance.

	Bioimpedance						
	MC	**FM**	**MSM**	**BMI**	**%F**	**WHR**	**VFA**
Anthropometry							
BMI	0.151†	0.853*†	0.177†	0.979*†	0.619*†	0.663†	0.853*†
WC	0.415†	0.665*†	0.428*†	0.843*†	0.528*††	0.540*†	0.781*††
WHR	0.559*†	0.284†	0.610*†	0.549*†	0.069††	0.227†	0.345††
%F	-0.442*†	0.791*†	-0.482*†	0.601*†	0.907*††	0.763*†	0.839*††
FW	0.011†	0.939*†	-0.003†	0.870*†	0.802*†	0.870*†	0.951*†
LBM	0.819*†	0.312†	0.835*†	0.522*†	-0.100†	0.306†	0.363†
BW	0.923*†	-0.021†	0.891*†	0.136†	-0.386†	0.121†	0.042†

BMI: body mass index; WC: waist circumference; WHR: waist-to-hip-ratio; %F: percentage of fat; FW: fat weight; LBM: lean body mass; BW: bone weight; MC: mineral content; FM: fat mass; MSM: musculoskeletal mass; VFA: visceral fat area; *: $p<0.05$; †: Spearman's correlation; ††: Pearson's correlation.

DISCUSSION

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This study assessed the correlation between two body evaluation methods, using anthropometry and the estimation of body composition and VFA by electric BIA in industrial workers to investigate discrepancies between the methods. In the study, the evaluations performed using the two techniques showed similar behavior, demonstrating a strong correlation between the variables BMI and BMIBIA, %F and %FBIA, FW and FMBIA, LBM and MSMBIA, BW and MCBIA, WC and VFABIA, indicating the possibility of using either of these methods to assess body composition.

Corroborating the obtained results, Fett et al., when comparing different methods of body composition assessment in overweight and obese sedentary women, submitted to two months of circuit or walking training, also found that the fat percentage means at BIA and anthropometry did not differ from each other and were significantly correlated. [17]

Machado, Coelho and Coelho, when comparing and evaluating the degree of agreement of body fat percentages in the elderly using three different methods: by the adipose area of the arm, by the tricipital skinfold (TSF) and by BIA, observed that all fat percentages had a statistically significant association with the anthropometric variables. According to the authors, %FBIA showed a better correlation with BMI, which reflects total body mass and WC, which reflects abdominal deposition and also that %FBIA showed a good correlation with the percentage of fat estimated by TSF, using Siri equation (%FSiri), demonstrating statistical significance. [1]

Similarly, this study found similar results, as the BMI, %F and WC by anthropometry showed a strong correlation with the FMBIA, BMIBIA and VFABIA for both evaluations. Martins et al. observed a correlation between the %F values obtained by the sum of the SFT and by BIA, when comparing these two methods of evaluation, disclosing a moderate association between them. [3] Andrade Jr. Clemente and Gomes identified a correlation between Body Fat and WC. [18]

Rezende et al., with the objective of verifying the efficiency of the BMI in identifying individuals with excess body fat and abdominal obesity, found that WC was the anthropometric measurement with the best correlation with BMI and with the %F estimated by BIA.[19] According to the authors, BMI showed high sensitivity in diagnosing individuals with %F and WC; however, in the individual evaluation, BMI was not adequate for this same diagnosis, due to the low positive predictive values found, confirming the need to use other anthropometric or body composition measurements in the assessment of nutritional status.

When classifying nutritional status, the use of BMI as a single measurement can cause equivocal evaluations, as it only estimates the association between individuals' weight and

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height, which can result in an incorrect diagnosis. BMI can show limitations in situations such as the association with body proportionality, i.e., individuals with short legs will have increased BMI; the fact that it does not consider the fat free mass ratio and muscular development, which may lead to misinterpretations in the identification of obesity; the correlation with height, which, although low, may be significant in children and adolescents and the loss of muscle mass (sarcopenia) and abdominal fat accumulation in the elderly. With aging, there is an increase in body fat, especially in the abdominal region, which can make the use of BMI increasingly limited for assessing nutritional status in this population, as individuals with normal weight and overweight individuals may also be at risk for metabolic alterations. [19,20]

Neves et al. found a higher correlation between ultrasound and BIA (0.767) than between BIA and body composition assessment using the SFT technique to estimate %F (0.742) and ultrasound with SFT (0.709) in young adults. [21] They identified a decrease in the correlations obtained when comparing all the methods in subjects with a BMI ≥25, and these results seem to reinforce the limitation of body assessment estimate in more obese subjects.

Nobuyuki et al. evaluated the reliability and validity of the octopolar multi-frequency BIA developed and made available in Korea (In-Body 720; Biospace, Seoul, South Korea) for body composition assessment in a Japanese sample, [22] comparing the results of InBody720 with those obtained by DEXA, finding a clear correlation between the results of percentage of body fat, muscle skeletal mass, LBM and MC.

Ling et al, in their study with 484 middle-aged subjects participating in the Longevity Study in the city of Leiden, in the Netherlands, assessed the precision of the multi-frequency segmental BIA (In-Body 720) in the assessment of different body composition parameters using DEXA as the reference standard.[15] The researchers concluded that BIA is a valid tool for assessing total body composition and segmental body in the general middle-aged population, particularly for the quantification of lean body mass.

The segmental Bia model (In-Body 720) includes the evaluation of VFA through the isolated analysis of the trunk, more accurately assessing this type of fat. [10] According to Lee et al., the BIA method can be considered safe and convenient to measure VFA when compared to the traditional CT assessment. [23] BIA has been considered sufficiently valid and safe. [24]

It can be considered that, although only two assessment methods were used, the non-use of a gold standard method, such as DEXA or CT, considered the reference methods, is justified because national and international studies indicate the use of multifrequency electric BIA (InBody720), as a highly reliable and valid method for determining body composition and VFA,

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and that the accuracy of the BIA method is well established. Moreover, as a limitation of this study, we must cite the sample size.[3,4,15,22,25]

The present study allowed us to conclude that the two methods showed similar behavior in body assessment, showing a strong correlation between variables of body fat and abdominal/visceral fat estimate, of lean mass and bone / mineral content by anthropometry and BIA, suggesting the possibility of using either of these techniques to evaluate body composition. Accurate body assessment measurements are crucial for the identification of body composition alterations and their implications for nutritional status in several clinical conditions. Therefore, because they are simpler, less expensive, practical, and reliable methods when compared to the gold standard, these two methods of evaluation can be considered as simple screening tools for the characterization of risk in individuals.

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ACKNOWLEDGEMENTS

To Secretaria da Ciência, Inovação e Desenvolvimento Tecnológico do Rio Grande do Sul, process number: 270-2500/11-5, and to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

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