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Original Article

ESTIMATION OF BODY MASS INDEX FROM SELF-REPORTED MEASURES: WHAT IS THE VALIDITY?

ESTIMATIVA DO ÍNDICE DE MASSA CORPORAL A PARTIR DE MEDIDAS AUTORREFERIDAS: QUAL A VALIDADE?

Luana Riris Maciel de Lima[1], **Rodrigo Pegado de Abreu Freitas**[1], **Layla Rafaela Dantas Silva**[1] and **Anna Cecília Queiroz de Medeiros**[1]

[1]Universidade Federal do Rio Grande do Norte, Santa Cruz-RN, Brasil.

RESUMO
O objetivo do estudo foi avaliar a utilização de medidas autorreferidas para calcular o índice de massa corporal (IMC) e estado nutricional. Foi realizado um estudo quantitativo transversal com amostra constituída de 1000 estudantes avaliados quanto ao peso corporal e estatura de modo mensurado pelos avaliadores e uma segunda medida informada pelos participantes. Foi identificada uma propensão a subestimação do peso corporal em 0,3 kg e superestimação da estatura em 1,0 cm, o que resultou em um IMC informado (IMC-i) menor que o IMC mensurado (IMC-M) ($p < 0,001$; $r = 0,34$). A confiabilidade do IMC-i, quanto à concordância com o IMC-M foi considerada muito alta. A avaliação do estado nutricional segundo o IMC-i resultou em um incremento do percentual de eutróficos (+ 2,3%) e diminuição de obesos (-3,2%), sendo maiores em homens (- 6,1%). Houve mudança na classificação do estado nutricional de 14,5% dos participantes quando avaliados a partir do IMC-i. Conclui-se que há boa concordância entre o IMC-i e IMC-M, porém, os resultados sugerem cautela em seu uso de forma isolada ou como uma variável contínua, parecendo ser mais adequada a utilização da informação categorizada, enquanto classificação de estado nutricional.
Palavras-chaves: Antropometria. Estudos de validação. Estado nutricional.

ABSTRACT
The aim of this study was to evaluate the use of self-reported measures for calculating body mass index (BMI) and nutritional status. A cross-sectional quantitative study was conducted on 1,000 students. Body weight and height were measured by a trained evaluator and were obtained by self-report of the participants. There was a trend towards underestimation of body weight by 0.3 kg and overestimation of height by 1.0 cm, which resulted in lower self-reported BMI compared to measured BMI ($p <0.001$; $r = 0.34$). Analysis of agreement with measured BMI showed very high reliability of self-reported BMI. The evaluation of nutritional status based on measured BMI resulted in an increase in the percentage of eutrophic individuals (+2.3%) and a decrease in obese individuals (-3.2%). This decrease was greater among men (-6.1%). A change in nutritional status classification occurred in 14.5% of the participants when evaluated by self-reported BMI. In conclusion, there is good agreement between self-reported and measured BMI, but the results suggest caution in the use of self-reported BMI alone or as a continuous variable. Categorized information seems to be more appropriate for the classification of nutritional status.
Keywords: Anthropometry. Validation studies. Nutritional status.

Introduction

Obesity is one of the most common modifiable risk factors for noncommunicable chronic diseases, which are responsible for more than 70% of deaths in Brazil. Within this context, the increase in the prevalence of Brazilians with excess body weight has led to actions designed to support strategies for the evaluation, coping and monitoring of this problem[1].

One of these actions are telephone surveys, such as VIGITEL, which cover all regions of the country and utilize self-reported body weight and height to monitor the nutritional and epidemiological profile of the adult population[2]. This strategy comes as a response to the fact that the measurement of anthropometric variables in population studies is time consuming[3,4] and requires equipment and trained evaluators, factors that imply the need for allocating greater financial resources for this purpose[4]. In this type of research, the subjects themselves are generally asked to provide the information about their body weight and height[5]. These self-reported data are then used to generate information for the development of health policies targeting risk factors and health promotion[6]. However, before the use of self-reported anthropometric measures, studies determining the magnitude of error associated with these data should be performed to validate these measures[5]. This concern stems from the possible under- or overestimation of the reported data, distorting the results related to body mass index (BMI) and generating incorrect assessments[3].

Studies conducted in different countries show that individuals tend to overestimate their height and to underestimate their body weight[6–8]. Women in particular evaluate their body weight lower than it really is, while men frequently overestimate their height[6,7,9]. Consequently, in contrast to measured anthropometric variables, the prevalence of overweight and obesity derived from self-reported data is generally lower[6].

In Brazil, the results of validation studies of self-reported anthropometric measures continue to be controversial[10], partly due to the wide sociocultural diversity[11], and relatively few studies on this topic are available, especially studies conducted in the Northern and Northeastern regions[12,13].

In view of this scenario, the objective of this study was to evaluate the impact of using self-reported measures for the calculation of BMI, and particularly for the classification of nutritional status, in an adult population from the state of Rio Grande do Norte.

Methods

This was a quantitative, cross-sectional study, which was approved by the Ethical Committee (No. 122.536/2012). All participants signed the free informed consent form.

Participants

The population consisted of university students from the campuses of three different cities, who volunteered after dissemination of the study in the social spaces of the university. Data were collected from 2013 to 2014, with the initial sample consisting of 1,119 students. The following inclusion criteria were established: age ≥ 18 years, enrolled in any course of the Federal University of Rio Grande do Norte, and no physical limitation that would impair the collection of body weight or height. Data collection was performed during the morning and evening courses.

Procedures

First, the participants answered a self-administered questionnaire about sociodemographic data and current body weight and height. Anthropometric assessment was performed immediately thereafter.

Body weight was measured to the nearest 100 g with a portable digital scale (Plenna®, São Paulo, Brazil; capacity of 150 kg). The scale was placed on a flat surface and the volunteers were asked to remove footwear, clothing, ornaments, and items from their pockets. Height was measured to the nearest 0.1 cm with a stadiometer made of anodized aluminum (Sanny®, São Paulo, Brazil; length of 115-210 cm) supported on a tripod. The participant was positioned with the back to the measuring rod, barefoot, standing fully erect with the feet together, the head in the Frankfurt plane, and the arms hanging loosely at the sides.

All measurements were made in duplicate by evaluators previously trained for this purpose. A third measurement was obtained in the case of discrepancy in body weight (± 100 g) and height (± 0.5 cm). The body weight and height measurements were performed according to the criteria proposed by Lohman et al. (1988)[14]. Outliers were detected using the Grubb test (Extreme Studentized Deviate method)[15].

The BMI was calculated using either the measurements obtained (BMI-m) or the data reported by the participants (BMI-r), and nutritional status was classified as suggested by the World Health Organization: BMI < 18.5 kg/m^2 (low weight); BMI ≥ 18.5 to 24.9 kg/m^2 (eutrophic); BMI ≥ 25 to 29.9 kg/m^2 (overweight), and BMI ≥ 30 kg/m^2 (obese) (WHO, 1995). The difference between the measured (BMI-m) and reported (BMI-r) values was defined as error, with negative values indicating overestimation of BMI and positive values indicating underestimation.

The agreement between BMI-m and BMI-r values was evaluated using the intraclass correlation coefficient (ICC), Lin's concordance correlation coefficient (CCC), and Bland-Altman plot[17]. The criteria described by Jonson and Gross[18] were adopted for the interpretation of ICC. Reliability was defined as very low (≤ 0.25), low (0.26-0.49), moderate (0.50-0.69), high (0.70-0.89), and very high (> 0.90)[18]. For CCC, the cut-off values proposed by McBride[19] were used: poor (< 0.90), moderate (0.90-0.95), substantial (> 0.95-0.99), and almost perfect agreement (> 0.99).

For determination of the limits of agreement (mean difference ± 2 standard deviations) obtained by Bland-Altman analysis[17], the limit of variation of ± 0.8 kg/m^2 proposed by Thomaz et al.[4] was adopted. This limit was established considering the usual fluctuation in body weight resulting from the variation between devices, as well as possible changes in the measurements over time between the last effective measurement and participation in the study [4].

The kappa coefficient was used to evaluate agreement between the classification of nutritional status based on BMI-m and BMI-r, as suggested by Fleiss[20]: excellent (k > 0.75), good (k > 0.40 and < 0.75), and poor agreement (k < 0.40). In addition, sensitivity, specificity and positive and negative predictive values were calculated for the classification of nutritional status based on BMI-r. The test efficiency was calculated as described by Kawamura[21], establishing a cut-off value of 75% as efficient.

The socioeconomic status of the participants was determined based on purchasing power measured according to the Brazilian Economic Classification Criteria[22]. From the score obtained, the students were classified into terciles of purchasing power.

Statistical analysis

The Mann-Whitney and Kruskal-Wallis tests were used for comparison between groups, and the Wilcoxon signed-rank test for intragroup comparison (BMI-r versus BMI-m). Statistical analysis was performed using the SPSS 19 and Medcalc 14.12.0 softwares. The level of significance adopted was $p < 0.05$.

Results

The initial sample consisted of 1,119 students; 118 were excluded because of the lack of reported information about body weight and/or height and one was considered an outlier according to the Grubb test. Thus, the final sample consisted of 1,000 volunteers, including 411 (41.1%) males and 589 (58.8%) females. The mean age of the participants was 21.3 (SD = 3.54) years. The students were enrolled at the campuses of Natal (59.5%, n = 595), Santa Cruz (21.2%, n = 212), and Caicó (19.2%, n = 192).

There was a trend towards underestimation of body weight by 0.3 kg and overestimation of height by 1.0 cm, which resulted in a lower median BMI-r when compared to BMI-m ($p < 0.001$; $r = 0.34$) (Table 1). Analysis of agreement with BMI-m according to ICC and CCC showed very high and moderate reliability of BMI-r, respectively.

Table 1. Descriptive statistics and assessment of agreement between body mass index calculated from measured (BMI-m) and self-reported data (BMI-r) in the adult population of Rio Grande do Norte. Brazil, 2013-2014

	BMI-m *(kg/m^2)**	BMI-r *(kg/m^2)**	Diference IMC (M-i) *(kg/m^2)**	CCC *(95% CI)*	ICC *(95% CI)*
Female *(n = 589)*	22.5 (20.5 ▪ 24.9)	22.0 (20.1 ▪ 24.3)	0.54 (-0.001▪ 1.09)	0.95 (0.94 ▪ 0.96)	0.95 (0.92 ▪ 0.97)
Male *(n = 411)*	24.3 (21.9 ▪ 26.7)	23.9 (21.7 ▪ 26.1)	0.46 (-0.07 ▪ 1.02)	0.93 (0.92 ▪ 0.95)	0.94 (0.91 ▪ 0.96)
Total *(n = 1.000)*	23.2 (21.0 ▪ 25.8)	22.8 (20.7▪ 25.2)	0.51 (-0.04 ▪ 1.06)	0.94 (0.93 ▪ 0.95)	0.95 (0.92 ▪ 0.96)

Legend: * Median (25th ▪ 75th percentile). 95% CI: 95% confidence interval; CCC: Lin's concordance correlation coefficient; ICC: intraclass correlation coefficient
Source: The authors

Bland-Altman analysis indicated a mean difference between BMI-m and BMI-r of 0.48 kg/m^2 ($p < 0.001$), with 54 participants being outside the upper (UL) (2.72 kg/m^2) and lower (LL) (-1.75 kg/m^2) limits of agreement (Figure 1). The mean difference between BMI-m and BMI-r was 0.47 kg/m^2 among men ($p < 0.001$; UL = 2.71 kg/m^2 and LL = -1.78) and 0.49 kg/m^2 among women ($p < 0.001$; UL = 2.72 kg/m^2 and LL = -1.73).

Compared to the results obtained with BMI-m, the assessment of nutritional status based on BMI-r resulted in an increase in the percentage of eutrophic volunteers (+ 2.3%) and a decrease in obese participants (-3.2%). This reduction in the percentage of obese individuals was notably greater among men (- 6.1%) (Figure 2). Overall, a change in nutritional status classification occurred in 14.5% of the participants when evaluated by BMI-r.

The agreement between the classification of nutritional status obtained with BMI-m and BMI-r was considered good in both the total sample (kappa = 0.72) and when analyzed separately by sex (male: kappa = 0.70 and female: kappa = 0.73).

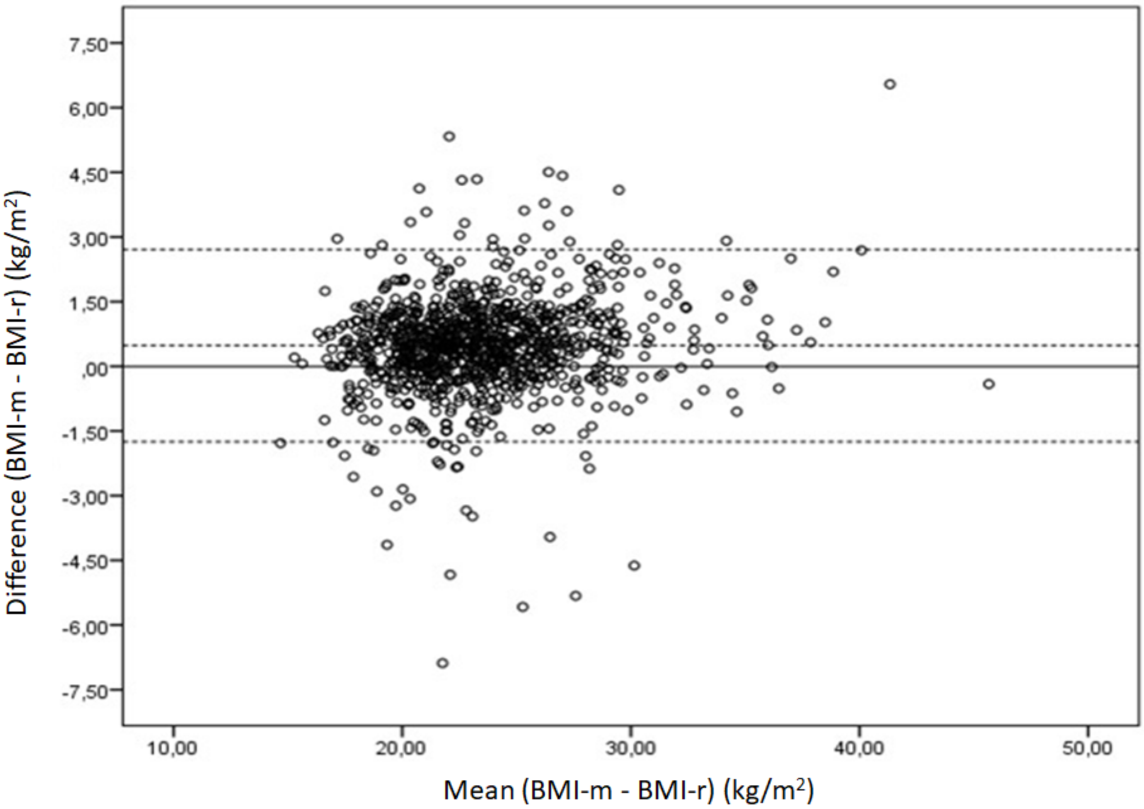

Figure 1. Bland-Altman plot showing the mean differences and 95% limits of agreement between body mass index calculated from measured (BMI-m) and self-reported data (BMI-r) in the adult population (n = 1,000) of Rio Grande do Norte. Brazil, 2013-2014

Source: The authors

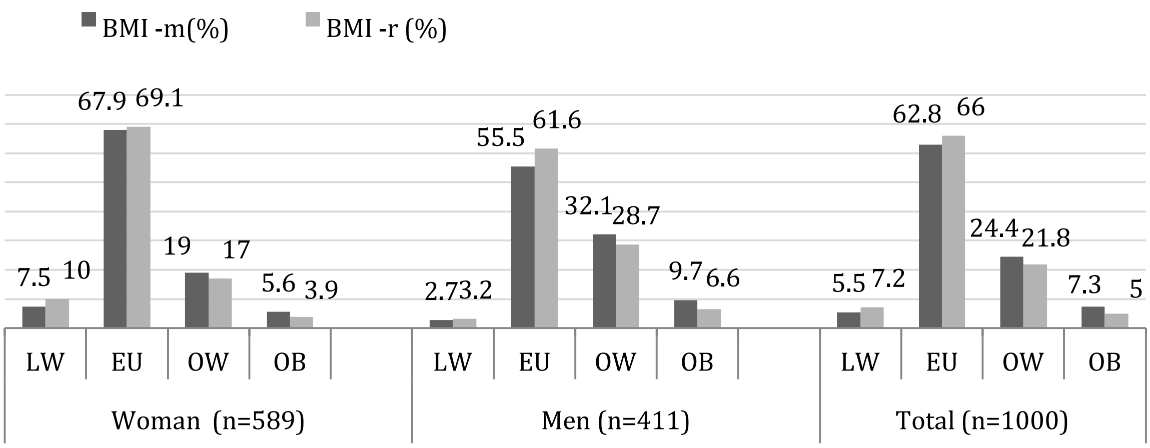

Figure 2. Classification of nutritional status based on body mass index calculated from measured (BMI-m) and self-reported data (BMI-r) in the adult population (n = 1,000) of Rio Grande do Norte. Brazil, 2013-2014.

Legend: L: low weight; EU: eutrophy; OW: overweight; OB: obesity

Source: The authors

The classification of nutritional status based on BMI-r showed high specificity in this population, but sensitivity was less than 80%. The highest test efficiency was observed for the diagnosis of obesity in women (99.1%) and the lowest for the detection of low body weight in men (76.4%) (Table 2).

A significant difference ($p < 0.001$) between BMI-m and BMI-r was observed in the total population and when stratified by sex. No significant difference between BMI-m and BMI-r was found between terciles of purchasing power ($p > 0.05$).

Table 2. Sensitivity, specificity, positive predictive value and negative predictive value for the diagnosis of low weight, overweight and obesity based on body mass index calculated from measured and reported data in the adult population of Rio Grande do Norte. Brazil, 2013-2014

	Female (n = 589)			Male (n = 411)			Total (n = 1,000)		
	LW	OW	OB	LW	OW	OB	LW	OW	OB
Sensitivity (%)	77.3	75.0	69.7	63.6	72.9	60.9	74.6	74.2	64.4
Specificity (%)	95.4	96.6	100	98.5	92.2	99.9	96.7	95.3	99.7
PPV* (%)	57.6	84.0	100	53.8	81.0	89.3	56.9	83.0	94.0
NPV** (%)	98.1	94.3	98.2	98.9	88.1	95.8	98.5	92.3	97.3
Test efficiency (%)	77.9	89.1	99.1	76.4	84.6	92.6	77.7	87.7	95.7

Legend: PPV: positive predictive value; NPV: negative predictive value; LW: low weight; OW: overweight; OB: obesity
Source: The authors

Discussion

In the present study, we found a tendency towards underestimation of mean BMI calculated from measured data when compared to BMI calculated from reported data, a trend reported in other Brazilian studies[23,24]. In addition, we observed high specificity and moderate sensitivity in the identification of low weight, overweight and obesity based on the reported measures. The highest efficiency of BMI-r was identified for the diagnosis of female obesity (99.1%) and the lowest efficiency for the diagnosis of low weight among men (76.4%), also showing high efficiency results.

These results corroborate those of another Brazilian study, which found a sensitivity and specificity of 88.2% and 96%, respectively, for overweight[23]. For obesity, sensitivity was 84.2% and specificity was 99.3%. As observed in the present study, the positive predictive value was higher among women. Oliveira et al.[12] reported sensitivity, specificity and positive predictive value of 92.9%, 78.4% and 76.5%, respectively, for BMI calculated from self-reported measures. Other studies demonstrated high sensitivity and specificity of self-reported BMI[4,5]. One peculiarity observed in this study was that specificity was higher than sensitivity in both sexes. The same phenomenon has been reported by Lucca and Moura[25] who evaluated 726 Brazilian adults.

The calculation of test efficiency uses sensitivity and specificity to obtain a value that indicates a certain degree of reliability and efficiency of the test performed[21]. However, we found no other studies using BMI-r for the classification of nutritional status that analyzed this parameter. The results obtained seem to support the use of self-reported body weight and height in the population studied, particularly in women in whom the efficiency of BMI-r for assessing obesity was 99.1%.

Despite these promising findings, when agreement between the measured and self-reported BMI categories was evaluated using the kappa statistic, agreement was only 0.71 for males and 0.73 for females. These values are lower than those reported by Silveira et al.[3] who studied subjects older than 20 years from the city of Pelotas and found a kappa of 0.86 for men and of 0.83 for women.

Corroborating these kappa values, evaluation of the percentage of subjects in each category of nutritional status based on the two BMI measures revealed an increase in the percentage of eutrophic and low-weight volunteers and a decrease in obese and overweight participants when BMI-r was used. Overall, there was a change in nutritional status classification in 14.5% of the participants when evaluated based on BMI-r.

Nevertheless, considering the results of efficiency, sensitivity and specificity, in young adults from Rio Grande do Norte self-reported anthropometric data should be used as BMI categories of instead of continuous variables. The misreporting of anthropometric measures can cause bias of attenuation or exacerbation in models that use these data for mathematical analysis[22]. One example are studies that use obesity (obtained from self-reported data) to develop socioeconomic models[26]. The distribution of these biases in the present study can be seen in the Bland-Altman plot.

The literature suggests that the ability to recall the last weight and height measurement is crucial for the reliability of self-reported measures[26,27]. This ability is influenced by ethnic and cultural factors, and especially by the educational level of each population studied[28,29]. Another point is that, regardless of the frequency of weighing, some individuals may have an erroneous perception or idea of their body, projecting a body image closer to the desirable one than the actual one, which seems to be relatively common among young adults[25].

One limitation of this study is the fact that, since all participants were university students and young adults, the educational level of the sample was higher and the age was lower than the mean observed in the Brazilian population[4]. These limitations should be understood as a warning sign. Since, in theory, these results are derived from a population with “improved” cognitive capacity and, even so, their use exhibits weaknesses, it appears to be of the utmost importance to investigate the quality of the data obtained in groups of older adults or with low educational level.

An educational approach should be advocated to encourage the periodic measurement of height and body weight in the population, which could also be used to promote the screening and monitoring of risk factors for chronic diseases. Since Brazil is a country of continental dimensions and great socioeconomic, cultural and educational heterogeneity, we highlight the need for further studies conducted in other regions and involving individuals of other age groups and educational levels to better contextualize the results found in the present study.

Conclusions

There is a trend towards underestimation of body weight and overestimation of height, which is influenced by sex and nutritional status. Although good agreement was observed between measures, the results suggest caution in the use of BMI-r alone or as a continuous variable. Categorized information seems to be more appropriate for the classification of nutritional status.

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Author addressd: Rodrigo Pegado de Abreu Freitas. Rua Vila Trairi, s/n - Centro. CEP 59200-000. Santa Cruz, RN, Brasil. E-mail: rodrigopegado@gmail.com