DOI: 10.1590/1809-4503201400030013

ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Validation and calibration of self-reported weight and height from individuals in the city of São Paulo

Validação e calibração de medidas de peso e altura autorreferidas por indivíduos da cidade de São Paulo

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ABSTRACT: ***Objective:*** To evaluate the validity of self-reported weight and height measurements among residents of São Paulo, as well as the accuracy of these measurements for determining nutritional status, and to present calibration coefficients. ***Methods:*** A cross-sectional, population-based study was performed with a sample of 299 adolescents, adults and elderly of both genders, in São Paulo in 2008. Bland-Altman difference plot and intraclass correlation were used to determine agreement between measured and self-reported parameters. Sensitivity and specificity were assessed for overweight, and calibration coefficients were estimated for correction of weight, height and body mass index data. ***Results:*** The intraclass correlation was high between self-reported and measured parameters for weight (r > 0,94) and body mass index (BMI) (r > 0,85). The agreement between measured and self-reported weight, height and BMI was good. Sensibility was > 91% and specificity was > 83%. ***Conclusion:*** Self-reported weight measurements can substitute measured parameters in this population, in both genders and in the age groups studied. Self-reported height measurements should be used with caution. Calibration coefficients can be used to adjust self-reported measurements.

Keywords: Validation studies. Sensitivity and specificity. Body weight. Body height. Body mass index, Health surveys.

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Conflict of interests: nothing to declare – **Financing source:** National Counsel of Technological and Scientific Development (CNPq) and São Paulo Research Foundation (FAPESP).

RESUMO: ***Objetivo*:** Avaliar a validade de peso e altura autorreferidos em residentes do município de São Paulo, a acurácia do uso dessas medidas na classificação do estado nutricional, bem como apresentar os coeficientes de calibração. ***Métodos*:** Foram utilizadas análises de Bland e Altman e correlação intraclasse para determinar concordância e validade entre as medidas aferidas e referidas, verificando sensibilidade e especificidade para excesso de peso. Também foram estimados os coeficientes de calibração para correção dos dados de peso, altura e índice de massa corporal (IMC). ***Resultados*:** Pode-se observar alta correlação intraclasse entre as medidas de peso ($r > 0,94$) e IMC ($r > 0,85$) referidas e aferidas. Também foi observada boa concordância entre as medidas de peso, altura e IMC, assim como alta sensibilidade (> 91%) e especificidade (> 83%) para IMC. ***Conclusão*:** Medidas autorreferidas de peso podem ser utilizadas em substituição às medidas aferidas nessa população de estudo, em ambos os sexos e nas faixas etárias estudadas. Já as medidas de altura devem ser utilizadas com cautela. Os coeficientes de calibração podem ser usados como estratégia para ajuste das medidas.

Palavras-chave: Estudos de validação. Sensibilidade e especificidade. Peso corporal. Estatura. Índice de massa corporal. Inquéritos Epidemiológicos.

INTRODUCTION

Overweight and obesity are increasing threats to the health of the world population and have been associated with several chronic diseases such as cardiovascular diseases, cancer, and diabetes[1]. In Brazil, the prevalence of overweight now reaches 50% of adults (20 – 59 years), 22% of adolescents (10 – 19 years) and 34% of children (5 – 9 years)[2]. This fact has motivated researchers to investigate factors associated (gender, age, education, income, lifestyle, etc.) to chronic diseases and identify groups at highest risk. Thus, the use of self-reported data and the use of self-administered questionnaires has been a common practice, especially in studies involving large samples[3]. This form of data collection is justified by its operational and logistical facility, in addition to the cost savings involved in training of personnel, transportation and procurement of equipment for measuring[4].

Self-reported measures of height and weight have been frequently used[5-8], However, it is common to find changes in the validity of the measurements according to characteristics of individuals, such as gender, age, nutritional status and socioeconomic (family income, education), cultural (valuation of thinness) and psychological (body satisfaction) conditions[9-11].

In the national literature, there are some studies on validation of height and weight measurements that show a greater tendency of underestimation of weight in obese individuals, adolescents and women, and overestimation of height in individuals of short stature, women, teens and seniors, which can generate a spurious estimate of body mass index (BMI), with a reduction of individuals at the extremes of the rating curve, compromising the validity of these measures[4,12-14]. To correct these potential errors, methodological strategies, such as using equations for calibration of the data, can be employed in order to bring the measure provided closer to the actual values. However, few studies develop such approaches.

Thus, the present study aims to assess the validity of self-reported data on weight and height of adolescents, adults and elderly residents of São Paulo, participants of Health Survey of São Paulo (ISA-Capital 2008), as well as to assess the agreement between classifications of nutritional status by self-reported and measured data, and to present calibration coefficients for correction of data on weight, height and BMI.

METHODS

This study is part of the Health Survey of São Paulo (ISA-Capital), a cross-sectional, population-based study conducted in São Paulo between 2008 and 2010. A sample of ISA-Capital was obtained by complex probabilistic sampling, by conglomerates, in two stages: census tracts and households (n = 1,662). The planning was done to estimate the proportions of 50% (p = 0.50, which corresponds to the largest minimum sample size for estimating proportions) with sampling error of 7 percentage points (d = 0.07) with a confidence level 95% and 1.5 design effects. Inclusion criteria of the ISA-Capital study were: being a resident of the selected household in the urban area of the state capital, belonging to the domains of interest (adolescents, adults and elderly of both sexes), not being pregnant. Details can be found in another publication[15].

In 2008, data on food habits and socioeconomic factors of the ISA-Capital study participants were collected through home visits. A year later, the team returned to the individuals' home to collect data such as measured weight and height, and other measures of interest (blood collection, blood pressure, medication use, among others) by a previously trained nurse. This second home visit for anthropometric measurements was confirmed by phone a few days before. Upon confirmation, the participant was asked about their height and weight measurements (self-reported), and dietary data were also collected.

During this period between the collections there was a significant sample loss, totaling 832 individuals who had reported anthropometric data and 750 who had and measured anthropometric data. However, this loss occurred randomly in all census tracts, thus reducing the possibility of bias by differential loss.

Some participants were not found at the time of the phone call (before the home visit). In such cases, this and other information of interest to the study (dietary and lifestyle data) were collected after the home visit and assessment of the measures. These latter individuals were excluded only from the present study because their data were measured prior to the time specified for data collection and may influence the outcome of the study.

Thus, for the present study, only individuals who had all their measurements collected and whose and self-reported measurements were collected before the measured values were selected, totaling a subsample from ISA-Capital of 299 individuals (112 men and 187 women, 62 adolescents, 107 adults and 130 elderly). However, no difference between schooling of head of household, age, sex and nutritional status between the study sample and the sample of ISA-Capital was observed.

For weight measurement, an electronic platform scale with capacity for 150 kg and sensitivity of 100 g (TANITA®) was used. Subjects were weighed wearing light clothes, barefoot with erect posture, parallel feet and fully supported in the balance platform and with arms along the body[16].

For height measurement, a stadiometer with scale in millimeters was used (Seca Bodymeter 208®), fixed to the wall. Subjects stood up with erect posture, feet together and heels touching the wall. The apex of the ear and the outer corner of the eye remained in parallel to the ground, forming an angle of 90 degrees to the bar of the stadiometer. The horizontal bar of the stadiometer was lowered and laid on the head, allowing reading in centimeters[16].

The self-reported data were obtained by the questions: "What is your weight?" And "How tall are you?".

From the measurements of weight and height, measured and reported BMI (weight/height^2) were calculated and classified according to the ranges suggested by Cole et al.[17] for teens, by the World Health Organization[1] for adults and by the Nutrition Screening Initiative for seniors.

The project was approved by the Research Ethics Committee of the School of Public Health, Universidade de São Paulo. All participants signed a free and informed consent form. There are no conflicts of interest.

STATISTICAL ANALYSES

Adherence of variables to normal distribution was checked by the Kolmogorov-Smirnov test, and presented normal distribution.

The intraclass correlation coefficients were used to assess the validity and relationship between reported and measured weight, height and BMI according to the categories of gender (male and female) and age (adolescent: 12 – 19 years, adult: 20 – 59; elderly: 60 years or older). This coefficient evaluates the correlation between the groups, considering the interpersonal variability, that is, the systematic under- or overestimation within the group[19]. Paired t-test was used to assess the differences between the means of reported and measured for each gender and age group.

The agreement between the measurements of weight, height and BMI was assessed by the strategy proposed by Bland and Altman[20], which includes the construction of a graph of agreement (mean versus agreement) and the calculation of the limits of agreement. By this technique, the magnitude of differences can be assessed for 95% of the observations.

Calibration coefficients were obtained by linear regression models, in which the reference pattern (measured) is modeled as a function of the self-reported measure[21-23]. Thus, the coefficients of attenuation can be estimated as the slope of the regression line of the reference values (measurements taken) in the observed data (self-reported measures). Calibration coefficients were estimated by gender and age group.

The use of calibration is important for extrapolating data; studies in the same population only with information on self-reported measures might use the data of calibration coefficients to improve estimates of means and confidence intervals for weight, height and BMI, decreasing the error in using the self-reported measure. This can be done by means of the equation: $y = B0 + B1x$, where y refers to the calibrated measure, x is the self-reported measure and B1 and represents the increase in the calibrated measure for each unit of the self-reported measure.

We calculated sensitivity, specificity and positive predictive value (PPV) of nutritional status, obtained from the BMI classifications (with and without excess weight), calculated from the reported measurements, taking as gold standard the BMI calculated from the measured values. The sensitivity and specificity were analyzed according to gender and age.

The proportions of individuals with excess weight were calculated from seld-reported, measured and calibrated data, and the proportion test was performed to verify the difference between measured and reported data, and between measured and calibrated data.

The sampling design of the ISA-Capital was not used in this study. The power of the study was verified for each domain of interest (adolescents, adults and elderly separated by gender), according to Reichenheim[24], who takes into account the confidence interval, Kappa, proportions and accuracy.

RESULTS

A total of 299 individuals living in the city of São Paulo (112 men and 187 women) were evaluated, 21% adolescents, 36% adults and 43% seniors. It was observed that 55% of the population had schooling of head of household with eight or more years of study. About 52% of people were overweight, and the prevalence was 36% for adolescents, 46% for adults and 64% for the elderly. This sample showed no statistical difference compared to the initial study sample by gender, age, education of household head and nutritional status (data not shown).

There was a high correlation ($r > 0.70$) between reported and measured weight, height and BMI, except for height in older women and adolescents, and adult men. There was no statistically significant difference between the mean reported and measured weight, height and BMI, except for the height of elderly females (Table 1). The Bland and Altman[20] analysis showed a good agreement between reported and measured weight and height, and the mean difference in weight (self-reported measure minus measure taken) was higher in adolescent males (1.11 kg). The average height difference was greater in elderly females (0.04 m) (Figures 1 and 2)

Table 1. Means of measured and reported weight, height and body mass index, mean error and intraclass correlation between reported and taken measurements according to gender and age. São Paulo, 2013.

		Mean measured	95%CI	Mean reported	95%CI	ICC	95%CI
Male							
Adolescent (n = 30)	Weight (kg)	60.62	56.52 – 64.72	61.74	58.22 – 65.26	0.91*	0.84 – 0.97
	Height (m)	1.75	1.72 – 1.76	1.73	1.71 – 1.76	0.76*	0.60 – 0.92
	BMI (kg/m²)	20.38	19.12 – 21.64	21.13	20.18 – 22.08	0.85*	0.75 – 0.96
Adult (n = 28)	Weight (kg)	76.24	70.89 – 81.59	76.15	71.58 – 80.71	0.95*	0.92 – 0.99
	Height (m)	1.73	1.71 – 1.75	1.74	1.71 – 1.77	0.59*	0.34 – 0.83
	BMI (kg/m²)	25.22	23.58 – 26.88	24.97	23.28 – 26.66	0.90*	0.82 – 0.97
Elderly (n = 54)	Weight (kg)	76.38	71.94 – 80.82	77.33	72.93 – 81.74	0.97*	0.95 – 0.99
	Height (m)	1.67	1.65 – 1.69	1.69	1.67 – 1.70	0.81*	0.71 – 0.90
	BMI (kg/m²)	27.47	26.24 – 28.70	27.2	25.96 – 28.44	0.93*	0.89 – 0.97
Female							
Adolescent (n = 32)	Weight (kg)	57.17	53.26 – 61.07	56.75	52.67 – 60.83	0.95*	0.91 – 0.98
	Height (m)	1.63	1.60 – 1.65	1.61	1.57 – 1.65	0.63*	0.40 – 0.85
	BMI (kg/m²)	21.46	19.80 – 23.12	22.16	19.68 – 24.63	0.74*	0.56 – 0.91
Adult (n = 79)	Weight (kg)	64.66	61.77 – 67.54	64.45	61.48 – 67.42	0.94*	0.91 – 0.97
	Height (m)	1.60	1.58 – 1.61	1.60	1.58 – 1.62	0.70*	0.59 – 0.81
	BMI (kg/m²)	25.23	24.07 – 26.39	25.17	23.93 – 26.41	0.86*	0.80 – 0.92
Elderly (n = 76)	Weight (kg)	70.04	66.62 – 73.47	69.66	66.59 – 72.73	0.94*	0.92 – 0.97
	Height (m)	1.54	1.52 – 1.56	1.58**	1.56 – 1.60	0.47*	0.29 – 0.66
	BMI (kg/m²)	28.85	27.53 – 30.15	27.46	26.22 – 28.70	0.87*	0.82 – 0.93

95%CI: confidence interval of 95%; ICC: intraclass correlation coefficient; BMI: body mass index; *p < 0.05; **statistically significant difference between reported and taken measurement (paired t-test, p < 0.05).

It was found that women tend to underestimate their weight and men (except adults) tend to overestimate it. Elderly individuals tend to overestimate height, while teenagers tend to underestimate it. Means, confidence intervals and intraclass correlation coefficients by gender and age group are presented in Table 1.

It is noteworthy that the correlation coefficients for height are lower in all age groups and gender. However, most are even greater than 0.40, which is considered a good value according to Fleiss[25].

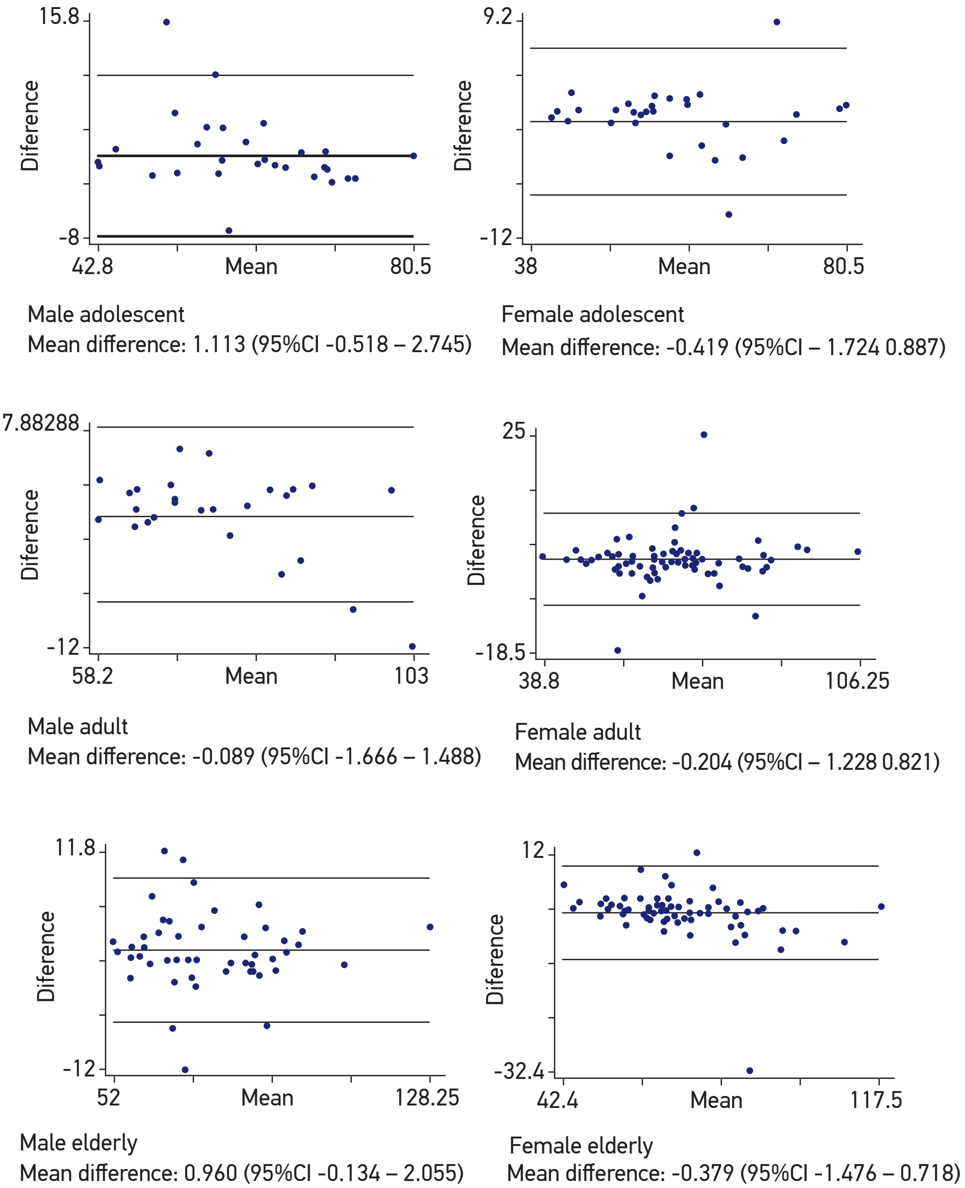

Figure 1. Bland and Altman plots for self-reported and measure weight (kg) according to sex and age group. São Paulo, 2013.

Calibration coefficients are presented in Table 2. Results related to height present lower coefficients of the regression models, especially among elderly women.

No significant difference was found in nutritional status according to measured and reported measurements, and according to measured and calibrated measures (Table 3).

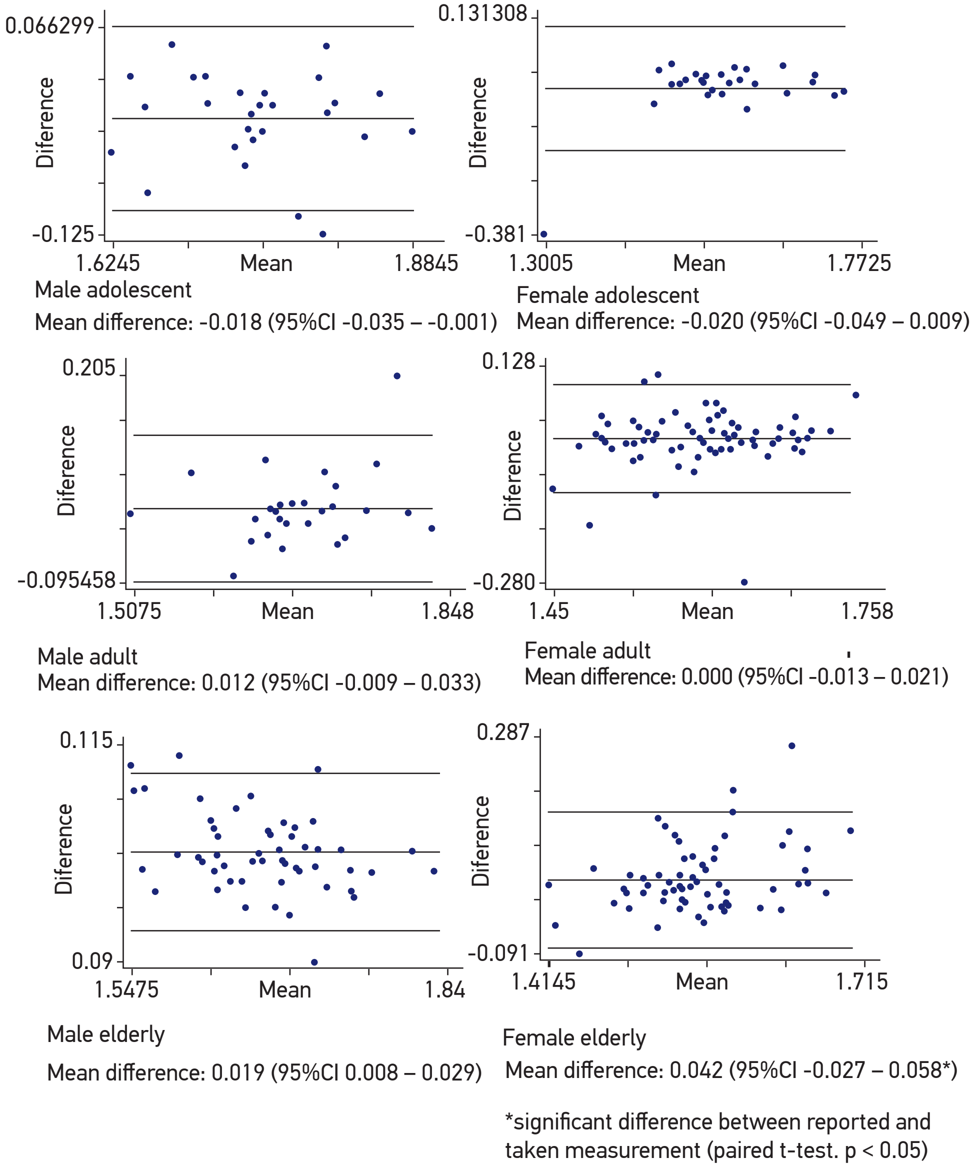

Figure 2. Bland and Altman plots for self-reported and measure height (m) according to sex and age group. São Paulo, 2013.

High sensitivity (> 91%) and specificity (> 83%) were found in all age groups and gender for BMI calculated based on reported data. There was also PPV > 82%, representing that 82% of individuals classified as overweight from reported measures are actually are overweight (Table 3).

Table 2. Calibration coefficients, confidence interval of the calibration regression according to gender and age range. São Paulo, 2013.

		B_0	B_1	95%CI
Male				
Adolescent (n = 30)	Weight	13.95	0.79	0.66 – 0.92
	Height	0.41	0.75	0.51 – 0.99
	BMI	7.03	0.69	0.57 – 0.82
Adult (n = 28)	Weight	13.57	0.82	0.72 – 0.92
	Height	0.45	0.75	0.04 – 0.80
	BMI	1.72	0.92	0.73 – 1.11
Elderly (n = 54)	Weight	4.09	0.96	0.89 – 1.03
	Height	0.51	0.70	0.58 – 0.82
	BMI	1.50	0.94	0.83 – 1.04
Female				
Adolescent (n = 32)	Weight	0.09	0.99	0.87 – 1.12
	Height	-0.44	1.01	0.58 – 1.45
	BMI	-3.26	1.18	0.81 – 1.56
Adult (n = 79)	Weight	1.77	0.97	0.89 – 1.05
	Height	0.39	0.76	0.58 – 0.93
	BMI	1.93	0.93	0.79 – 1.05
Elderly (n = 76)	Weight	10.04	0.85	0.79 – 0.92
	Height	0.81	0.34	0.56 – 1.05
	BMI	2.66	0.86	0.76 – 0.96

B_0: linear coefficient; B_1: slope; IC95%: confidence interval of 95%.

DISCUSSION

This study is the first to assess the feasibility of using self-reported measures of height and weight in a subsample of a population-based study with a representative sample of adolescents, adults and elderly residents of São Paulo, as well as presenting calibration coefficients for correction of self-reported data.

The results of this study are better than those reported in the literature, as there was a good correlation between measurements of weight and height for the calculation of BMI in all age groups and gender[4,9,13]. Differences observed between reported and measured weight were not significant for either gender and age groups, that is, were proved void.

Table 3. Sensitivity, specificity and positive predictive value of body mass index determined from reported measurements and proportion of subjects with overweight from taken, reported and calibrated measurements and their differences. São Paulo, 2013.

	Sensitivity (%)	Specificity (%)	PPV (%)	Measured overweight (%)*	Self-reported overweight (%)*	Calibrated overweight (%)*
Adolescent	91.67	97.67	95.65	35.82	34.33**	34.33***
Adult	92.16	83.33	82.46	45.95	51.35**	49.55***
Elderly	95.70	94.34	96.74	63.70	63.01**	58.22***
Male	91.67	92.06	92.06	48.78	48.48**	46.34***
Female	95.37	90.32	91.96	53.73	55.72**	52.74***

PPV: positive predictive value; *proportion of overweight; **statistically significant difference between the proportions of measured and reported overweight (ratio test); ***no statistically significant difference between the proportion of measured and calibrated overweight (ratio test).

Some of the factors that could affect these results are the frequency with which individuals weigh themselves, the date of last measurement, type of clothing and footwear used, excessive preoccupation with body image and dissatisfaction with weight[4,9]. In addition, access to and frequency of use of the primary health care network in São Paulo may have influenced the higher frequency of measurement of weight, bringing the self-reported value closer to the real one[26].

It was observed that older women overestimated their height, in accordance with what Del Duca et al[14] observed in the elderly of both sexes of Pelotas, Rio Grande do Sul. This fact is possibly due to the low frequency of measurement and the natural reduction in height due to the compression of the intervertebral discs[27].

It was also found that the majority of calibration coefficients was close to one, indicating that these self-reported measures have good equivalence with the measurements taken[28,29]. The use of calibration coefficients can help in a more reliable prediction in studies with only self-reported measures. However, the coefficient of height proved to be distant from one, so the use of self-reported height, especially among the elderly, should be done with caution.

The prevalence of overweight according to the self-reported or calibrated measure was statistically the same as measured, showing that the use of such measures for nutritional diagnosis of overweight is valid. The prevalence from the calibrated measurements tended to be mostly closer to the measured value compared with the prevalence from the self-reported results. Thus, the use of calibration coefficients presented in this study as enhancement factors may favor the accuracy of association measurements obtained in epidemiological studies when arising from self-reported anthropometric weight and height measurements.

The sample size in stratified analyzes led to the reduction of the power of the study. However, can still be considered that the results of mean difference and correlation were homogeneous in their majority, no changes were found in BMI classifications in this study, which can be seen from the values of sensitivity, specificity and positive predictive value.

It is also noteworthy that, even though this study has a small sample, this resembles the original study population of ISA-Capital in socioeconomic data and nutritional status.

CONCLUSION

We conclude that the method of self-reported measures showed good validity with measures taken for most of the population studied and showed high sensitivity and specificity. Height measurements should be used with caution. Calibration coefficients presented can be used to improve BMI estimates and overweight prevalence in this study population. These data are important as they enable future studies to be developed with economy of resources and simplified field work.

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Received on: 10/03/2013
Final version presented on: 12/24/2013
Accepted on: 05/09/2014