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# Consistency between anthropometric measures in national survey

## ABSTRACT

**OBJECTIVE:** To analyze the consistency between height and weight values obtained by direct measurement and reporting in contemporary national surveys.

**METHODS:** A group of 20 to 39 year olds were selected in the Household Budget Survey (POF) and Surveillance System of Protective and Risk Factors for Chronic Diseases by Telephone Survey (VIGITEL), 2008 and 2009. The surveys were matched by sex and age. For inference about the comparison between standardized (POF) and self-declared (VIGITEL) height and weight values used the Student t test and the Spearman estimator (ρ). The consistency between anthropometric indexes and indicators in the two surveys was estimated by the estimators of Lin (Φ) and Pearson (r).

**RESULTS:** Weight and height results were higher than those measured in a standardized way. The correlation of average height in the two surveys was ρ = 0.31 in women and ρ = 0.62 in men. The association was ρ = 0.86 and 0.88 respectively, for weight. Body mass index showed a strong correlation and agreement of approximately 0.90 for the two estimators in both sexes. The agreement between the diagnosis of obesity from the values of the measured and self-declared surveys was Φ = 0.89 in men and Φ = 0.91 in women.

**CONCLUSIONS:** Reported height and weight follow the same bias as those measured standardly and eliminates distortion in estimated indices and indicators in both surveys. The declared anthropometric values show good prospects for use in other analyses involving determinants of health and nutrition.

**DESCRIPTORS: Body Weights and Measures, methods. Anthropometry, methods. Diagnostic Self Evaluation. Techniques, Measures, Measurement Equipment. Reproducibility of Results.**

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## INTRODUCTION

The question of whether there are differences in reported and directly measured anthropometric data and, if so, the size and direction of this difference has been answered by an experiment which compares the two types of data directly, using the subjects themselves as control.

The responses obtained in such an approach indicate that height and weight reported by the subject differ from the values obtained when measured by an experienced anthropometrist.[10,19] The reported values tended to overestimate height and underestimate weight,[10,15,23] although these differences did not appear to be affected by the age[22] or height[5] of the subject. In some studies, the clinical impact of the comparison was shown to be higher among women than in men.[3,6,7]

These responses and evidence do not encompass all the complexity of the problem and sideline the ultimate aim of population based surveys: to produce valid estimates for the population studied. This aim broadens the comparison between reported and directly measured anthropometric data, as the sources of variation include the surveys themselves, even when only median values are used. The method which uses the subjects themselves as control for analyzing the variability between measured and reported anthropometric values is not sufficient and is not relevant to address the reliability or consistency of data obtained in population studies.[20]

Rather than comparing measured and reported values, measured values taken at an unspecified time and in a non-standard was are compared with measured values taken in a standardized way at the time of the survey.[11,12] Thus, using the individual as control in the analysis has the disadvantage of introducing a favorable bias to standardized direct measurement, as all of the noise of the comparison, including that which has nothing to do with the individual, is concentrated in the reported measurement.

The irrelevance of analysis based on individuals for the validity or reliability of the measures in population studies is because typical variability which occurs between surveys is discounted.[20] Therefore, in this type of analysis, the variability of anthropometric measures taken at different times and, by extension, the variability of the anthropometric values of the same cohort between surveys, remains unanswered.

The ecological approach between cohorts seems more suitable and informative for analyzing the difference between population based anthropometric data that is self-reported by the interviewee and standardized direct measurements taken during the survey. This approach does not resolve all of the problems previously outlined, but it allows a more consistent analysis and interpretation of the differences.

This study aimed to analyze the consistency between reported height and weight values and those obtained by direct measurement in recent national surveys.

## METHODS

The VIGITEL (Surveillance System of Protective and Risk Factors for Chronic Diseases by Telephone Survey), established by the Brazilian Ministry of Health in 2006, is a system which monitors annually the frequency and distribution of the principal risk factors associated with non-communicable chronic illness in the Brazilian population. The basic VIGITEL[a] sample is composed of at least 2,000 individuals aged ≥ 18 in the Federal District and in each state capital. Adjusting the sample for the total population of the country takes place in two stages: in the first stage, the weighting is a function of the probability of being selected and of having a landline in the universe of each city studied; in the second stage, this is the relationship between the frequencies of the sex, age group and schooling categories in the VIGITEL[a] sample and in IBGE (Brazilian Institute of Geography and Statistics) Demographic Census. Details of the VIGITEL sample procedures are described in Kuczmarski et al.[12]

The Household Budget Survey (POF) is a national survey conducted by the IBGE[b] in both urban and rural areas throughout the country, with all states represented. The permanent private residences in the sample are drawn within clusters distributed according to census tracts grouped by socioeconomic strata. The POF collects demographic data, data on the household budget and measures the height and weight of all individuals in the sample.[b]

The VIGITEL 2008 and 2009 samples were drawn from all cases aged ≥ 20 and < 40 years old, giving a total of 103,164 cases selected (44,071 men and 59,093 women). Data from women who were pregnant or suspected they were pregnant had been previously excluded from the samples. Data from the 2008-2009 POF on individuals aged between 20 and 40 and on residents in the state capitals and metropolitan areas

[a] Ministério da Saúde. VIGITEL Brasil 2008: Vigilância de fatores de risco e proteção de doenças crônicas por inquérito telefônico: estimativas sobre freqüência e distribuição sócio-demográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2008. Brasília (DF); 2009.

[b] Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa de Orçamentos Familiares 2008-2009 Antropometria e estado nutricional de crianças, adolescentes e adultos no Brasil. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística; 2010. [cited 2011 Jan 5]. Available from: http://wwwibgegovbr/home/estatistica/populacao/condicaodevida/pof/2008_2009/POFpublicacaopdf

covered by VIGITEL were used. The estimates took into consideration the weighting factors in each survey.

In the VIGITEL survey, height and weight were reported by the subjects.[14] In the POF survey height and weight values were measured in a standardized way in the subjects' own residences. Body Mass index was calculated dividing weight (kg) by height$^2$ (m) and frequency of underweight (BMI < 18.5 kg/m$^2$) and obese (BMI ≥ 30 kg/m$^2$) individuals was estimated, according to critical values for adults adopted by the World Health Organization.[24]

The analysis of consistency between reported and directly measured values in 2008-2009 were based on the premise that, in all of the comparisons, the values presented represent a mean estimate of the Brazilian population in the state capitals and metropolitan areas.

The height and weight means were stratified year on year from 20 to 29 years old and biennia between 30 and 39 years old to maintain the homogeneity of the sample.

The VIGITEL and POF height and weight means were compared statistically for each age with values effectively measured using the student's t-test. The *p* values < 0.05 were considered significant. The correlation of mean height and weight values between the two surveys was obtained using the Spearman estimator.

The consistency between estimated anthropometric indicators based on measurements (POF) and on reported values (VIGITEL) in the Brazilian population in 2008-2009 was analyzed using Pearson (r) and Lin (Φ) estimators according to sex and age group.

To show the effect of the reported and directly measured measurements, the values for height, weight and Body Mass Index were log-transformed and the differences versus the means plotted, as proposed by Bland & Altman.[2]

The analyses were carried out using the Stata® version 11 software package.

## RESULTS

Differences in values for height between POF and VIGITEL presented no systematic characteristics in men and were not associated with age. Differences in values for weight were not associated with age and the difference between means was not statistically significant at any age. There was no link between the differences in mean weight and the differences in mean height, i.e., when mean weight was higher in VIGITEL, mean height did not follow any trend of being higher or lower (Table 1).

Ten of the 15 difference in height values were statistically significant for women. The mean height in

**Table 1.** Means of height and weight values as collected by the VIGITEL system and the POF survey, according to sex and age group. Brazilian capitals and the Federal District, 2008-2009.

| Age (years) | Height | | | | Weight | | | |
|---|---|---|---|---|---|---|---|---|
| | Male | | Female | | Male | | Female | |
| | Male | Female | Male | Female | POF | VIGITEL | POF | VIGITEL |
| 20 | 173.3 | 171.7[a] | 162.8 | 161.9[a] | 69.4 | 70.7 | 59.4 | 58.2[a] |
| 21 | 174.7 | 175.7[a] | 160.0 | 161.9[a] | 73.0 | 73.8 | 58.6 | 60.8[a] |
| 22 | 174.0 | 173.7 | 162.8 | 162.7 | 71.3 | 70.5 | 60.3 | 60.8 |
| 23 | 173.5 | 173.5 | 161.7 | 162.8[a] | 72.6 | 73.9 | 59.6 | 61.3[a] |
| 24 | 174.0 | 173.8 | 162.3 | 162.5 | 73.0 | 73.4 | 61.8 | 60.7 |
| 25 | 172.8 | 173.1 | 161.8 | 162.6[a] | 73.2 | 74.4 | 63.5 | 61.5[a] |
| 26 | 174.5 | 175.3 | 160.7 | 162.2[a] | 75.3 | 75.7 | 60.5 | 61.4 |
| 27 | 174.2 | 173.9 | 161.0 | 162.8[a] | 76.8 | 77.5 | 62.5 | 62.4 |
| 28 | 174.0 | 173.5 | 161.6 | 162.3 | 77.2 | 76.4 | 63.6 | 62.6 |
| 29 | 172.7 | 173.7[a] | 161.2 | 161.4 | 75.5 | 77.5 | 62.4 | 62.7 |
| 30 | 173.1 | 173.1 | 160.2 | 162.4[a] | 77.7 | 76.6 | 63.3 | 64.4 |
| 32 | 172.2 | 173.0 | 161.1 | 161.3[a] | 76.8 | 76.5 | 64.5 | 64.9 |
| 34 | 172.6 | 172.8 | 160.6 | 161.5 | 78.2 | 77.5 | 64.6 | 65.2 |
| 36 | 173.3 | 172.7 | 160.1 | 161.7[a] | 78.9 | 79.0 | 63.9 | 65.4 |
| 38 | 172.4 | 172.5 | 160.3 | 161.2[a] | 78.2 | 77.4 | 65.2 | 65.5[a] |
| Spearman | 0.62 | | 0.31 | | 0.86 | | 0.88 | |

[a] $p < 0.05$
VIGITEL: Surveillance System of Protective and Risk Factors for Chronic Diseases by Telephone Survey
POF: Household Budget Survey

VIGITEL was higher than that in POF in eight cases. In ten comparisons, VIGITEL values exceeded those of POF for weight and in all of the comparisons of over 30s. The values for height were higher in VIGITEL in almost all of the comparisons. The VIGITEL values exceeded mean values in the POF in the majority of comparisons of weight values (Table 1).

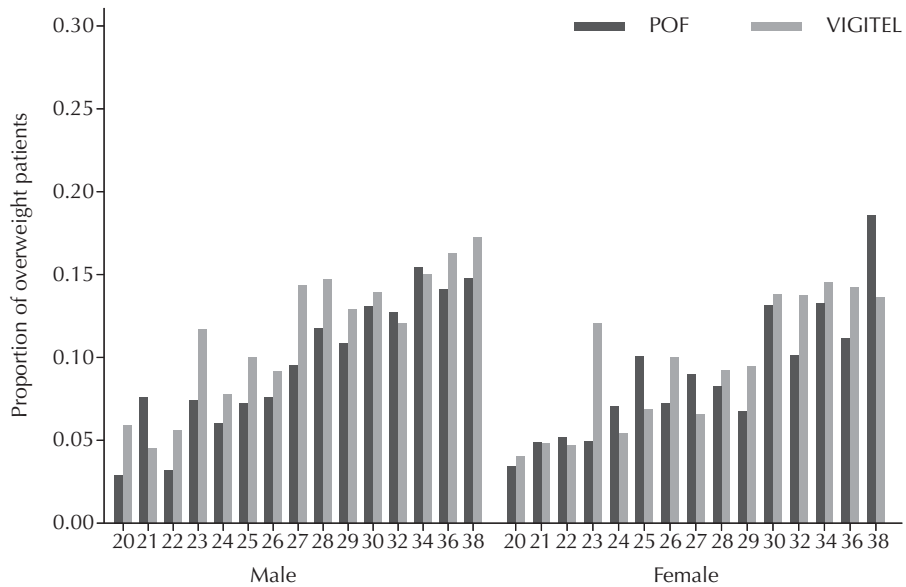
Correlation between mean height values in the two surveys was greater among men than women. With regards to weight, there was a strong association between reported and measured values for both sexes (Table 1).

BMI based on reported height and weight values showed high concordance (Φ) and correlation (r) with that calculated from directly measured values for both sexes (Table 2). Stratification of the comparisons by age shows, however, fewer similarities between the two surveys, especially in the classification of women as underweight or obese.

**Table 2.** Pearson (r) and [Lin (Φ)] coefficients between anthropometric indicators estimated based on directly measured (POF) and reported (VIGITEL) according to sex and age group in the Brazilian adult population. Brazilian capitals and the Federal District, 2008-2009.

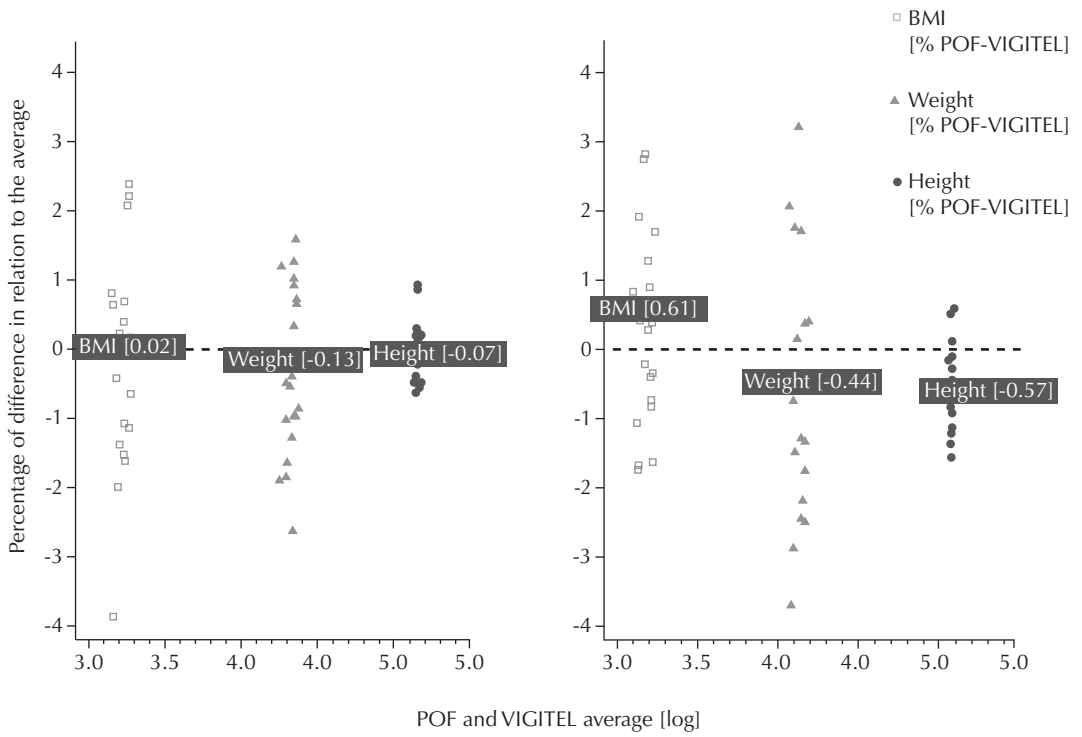
| Sex and age | BMI (kg/m2) | | | Underweight | | | Obese | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lin (Φ) | Bias | Pearson (r) | Lin (Φ) | Bias | Pearson (r) | Lin (Φ) | Bias | Pearson (r) |
| Male | | | | | | | | | |
| 20 to 24 | 0.41 | 0.23 | 0.48 | 0.32 | 0.06 | 0.37 | 0.31 | 0.02 | 0.40 |
| 25 to 29 | 0.78 | 0.17 | 0.86 | -0.02 | 0.01 | -0.03 | 0.43 | 0.03 | 0.87 |
| 30 to 34 | 0.04 | -0.29 | 0.08 | 0.01 | 0.02 | 0.04 | -0.40 | 0.00 | -0.40 |
| 35 to 39 | 0.04 | -0.15 | 0.06 | -0.14 | 0.01 | -0.41 | 0.15 | 0.01 | 0.23 |
| 40 to 49 | 0.89 | -0.01 | 0.91 | 0.35 | 0.01 | 0.46 | 0.71 | 0.02 | 0.76 |
| Female | | | | | | | | | |
| 20 to 24 | 0.51 | 0.08 | 0.52 | 0.17 | 0.03 | 0.40 | 0.05 | 0.01 | 0.09 |
| 25 to 29 | 0.08 | -0.48 | 0.17 | -0.05 | 0.04 | -0.86 | -0.86 | 0.00 | -0.87 |
| 30 to 34 | 0.72 | -0.02 | 0.77 | 0.34 | 0.00 | 0.48 | -0.43 | 0.01 | -0.86 |
| 35 to 39 | 0.62 | -0.01 | 0.63 | -0.33 | 0.02 | -0.57 | 0.06 | 0.00 | 0.07 |
| 40 to 49 | 0.91 | -0.11 | 0.92 | 0.49 | 0.02 | 0.62 | 0.61 | 0.01 | 0.62 |

VIGITEL: Surveillance System of Protective and Risk Factors for Chronic Diseases by Telephone Survey
POF: Household Budget Survey




VIGITEL: Surveillance System of Protective and Risk Factors for Chronic Diseases by Telephone Survey
POF: Household Budget Survey

**Figure 1.** Prevalence of obesity, according to age and sex, estimates based on measured (POF) and reported (VIGITEL) data in the adult Brazilian population. Brazilian capitals and the Federal District, 2008-2009.




VigitelI: Surveillance System Risk and Protective Factors for Chronic Diseases Survey Telephone
POF: Household Budget Survey

**Figure 2.** Differences and means (on a logarithmic scale) for weight, height and BMI values by sex, estimates based on measured (POF) and reported (VIGITEL) data in the adult Brazilian population. Brazilian capitals and the Federal District, 2008-2009.

The VIGITEL values were higher than those estimated in the POF for the same age groups in men. In women, the expression of higher values in the obesity estimates varied between 20 and 29 years old and tended to be higher in VIGITEL from this age and upwards (Figure 1).

The dispersion of differences proportional to the mean between the two surveys was greater among females than males, notably for weight values. For women, the height and weight values in VIGITEL exceeded those observed in the POF by an average of around 5%. For males, the trend for VIGITEL values to exceed POF values still existed, although in magnitudes the proportional differences of which were close to zero (Figure 2).

## DISCUSSION

Comparison between reported and directly measured height and weight values in the Brazilian population of the state capitals and the Federal District in 2008-2009 shows: a) height and weight values reported by the interviewee tend to be higher than those directly measured in the same population; b) men are less imprecise and inexact than women when providing anthropometric data; c) overall estimates based on BMI calculated using reported or measured values are relatively close; d) there is greater variability in obesity estimates when stratified by age; e) the differences between measured and reported values are more pertinent to females. By restricting the age range in the study, this analysis avoided the results being influenced by anthropometric fluctuations typical of growth completion in adolescence and of ageing.

The fact that reported height and weight values are higher than measured values is widely documented and recognized in diverse studies on the topic.[6,9,21] These studies, however, refer to analytical designs using the subjects themselves as control. The data reported here may represent an agglomeration of values originally obtained by unstandardized measuring technique, carried out by untrained anthropometrists.

Among men, the mean estimate for the population, based on reported anthropometric values, does not differ from than based on directly measured values in the same population. For women, however, the differences between reported and measured values are statistically significant, and proportionally higher, in the case of weight. The profile of the differences for

females means that BMI based on measured values was a mean 0.6% higher.

With the exception of a study carried out in Italy, which reported differences of approximately 1 kg/m² in both sexes, the majority of studies describing discrepancies in reported and measured anthropometric values,[3,4,18] the difference in BMI does not exceed 0.5 kg/m².

Comparison of the results of this study with those of other published analyses on the topic raises two relevant points. The first concerns the possibility of using data for anthropometric estimates about the population studied and the use of anthropometric data in studies related to risk factors for health; the second concerns the less exact and precise nature of the data for females in relation to the anthropometric values in question.

Using these anthropometric data to estimate BMI or indicators of obesity in the population studied provides reliable and relatively precise data with regards to the values which are conventionally used, from surveys in which anthropometric measures are taken in a standardized way in the subjects' homes. Precision tends to fall as then analyses and their associations are stratified by sex and age group. The variations in BMI estimates (up to 3.0% on average) do not appear to be sufficient to distort overall estimates or studies of associations between anthropometric values and risk factors for health.

Estimates from unpublished data originating from anthropometric training in the Population Nutrition Evaluation Laboratory of the Nutrition Department of Sao Paulo University indicate that measures taken using unstandardized measuring procedures or by less experienced anthropometrists tend to increase the anthropometric values, which provides a reasonable explanation for some of the findings of this study.[c] The lower precision and exactitude in the anthropometric values reported by women are more difficult to explain, although the results are in line with those of other analyses published in Brazil[9] and in other countries.[2,6,13,17,23] It may be that women are less exposed socially to systematic measuring processes. This occurs in the case of men, for example when undergoing their physical checks for military service, which is obligatory in Brazil. The fact of being less exposed to standardized measuring undertaken by trained anthropometrists using correctly calibrated equipment means women are more exposed to measuring themselves opportunistically (equipment in pharmacies, for example) or to the effects of psychological perception on body size.[8,16]

If true, these hypotheses have more impact on variability of weight values than height values, as observed in Figure 2. The greater variability in weight values among women is directly linked to opportunistic measuring.

The results here indicate that overall estimates of nutritional states obtained based on reported anthropometric measures are consistent with those based on directly measured values for the same population in equivalent periods. More stratified estimates show greater imprecision in the results, especially for females. The main nutritional trends in the population will not be affected by stratifying the analyses.

The results show the relevance and usefulness of VIGITEL style surveys in monitoring overall values and main trends in the nutritional state and its association with health risks in countries with similar structures to Brazil. These data open good prospects of using the anthropometric values of this monitoring activity in other analyses involving health and nutrition determinants.

[c] Correspond to 150 measurement procedures collected in 15 regular trainings and analyzed specifically according to hypothesis presented.

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