

Comunicación breve

# Intraobserver error associated with anthropometric measurements made by dietitians

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## Abstract

**Introduction:** Although dietitians play an important role in the anthropometric assessment, reports on measurements made by these health professionals rarely include estimates of measurement error.

**Aim:** To estimate of intraobserver precision for three common anthropometric measurements made by dietitians.

**Methods:** Twenty six measurers performed measurements (upper mid-arm circumference, tricipital and bicipital skinfold) in two times a sample of ten volunteers. Four precision estimates were calculated: the technical error of measurement (TEM), the relative technical error of measurement (rTEM), the coefficient of reliability (R) and the coefficient of variation (CV).

**Results:** For skinfold thickness, rTEM was smaller than 2.2; for circumference, rTEM was smaller than 0.6. The precision to measure skinfolds was lower than the precision to circumference. Anyway, for all measurements R showed a high degree of precision (R > 95).

**Conclusion:** Our results suggest that anthropometric parameters evaluated are sufficiently precise. However, periodical training is necessary to control and minimize the anthropometric measurement error.

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Key words: Precision. Skinfold thickness. Circumference. Intraobserver variability. Technical error of measurement.

## ERROR INTRAOBSERVADOR ASOCIADO A MEDIDAS ANTROPOMÉTRICAS REALIZADAS POR DIETISTAS

### Resumen

**Introducción:** Aunque los dietistas desempeñan un papel importante en la evaluación antropométrica, las medidas registradas por estos profesionales sanitarios normalmente no incluyen estimación de errores de medida.

**Objetivo:** Estimar la precisión intraobservador de tres medidas antropométricas habituales realizadas por dietistas.

**Métodos:** Veintiséis medidores realizaron en dos ocasiones las medidas (circunferencia media del brazo, pliegue tricipital y bicipital) a una muestra formada por diez voluntarios. Se calcularon cuatro estimaciones de precisión: el error técnico de medida (ETM), el error relativo técnico de medida (ERTM), el coeficiente de fiabilidad (F) y el coeficiente de variación (CV).

**Resultados:** Para los pliegues, el ERTM fue menor de 2,2 y para la circunferencia el ERTM fue menor de 0,6. La precisión para medir los pliegues fue menor que para la circunferencia. De todos modos, para todas las medidas efectuadas la F mostró un elevado grado de precisión (F>95).

**Conclusión:** Nuestros resultados sugieren que los parámetros antropométricos evaluados son lo suficientemente precisos. Sin embargo, es necesario un entrenamiento periódico para controlar y minimizar los errores de las medidas antropométricas.

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Palabras clave: Precisión. Pliegues adiposos. Circunferencia. Variabilidad intraobservador. Error técnico de medida.

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## Abbreviations

a, average of the first measurement  
b, average of the second measurement  
BS, bicipital skinfold  
CV, coefficient of variation  
d, difference between the first and second measurement  
MAC, upper mid-arm circumference  
N, number of volunteers measured  
R, coefficient of reliability  
rTEM, relative technical error of measurement  
SD, standard deviation  
TEM, technical error of measurement  
TS, tricipital skinfold  
VAV, variable average value  
 $\bar{X}$ , average

## Introduction

Because of its importance to health, body composition is commonly investigated in epidemiologic, clinical, and population studies. Several direct and indirect methods are available to study the body composition, by the use of a specific technique mostly determined by time and financial expense<sup>1</sup>. The most practical, simple, inexpensive and noninvasive technique is anthropometry<sup>2</sup>.

Although the need for precise anthropometric measurement has been repeatedly stressed, reports on physical measurements in human populations rarely include estimates of measurement errors. In the anthropometric literature, precision refers to the degree of variability between repeated measures on a subject by the same observer (intraobserver precision) or by different observers (interobserver precision)<sup>3</sup>.

The most commonly used measures of precision are the technical error of measurement (TEM) and the coefficient of reliability (R). The use of two errors estimates, TEM and R, can provide most of the information needed to determine whether a series of anthropometric measurements can be considered precise<sup>4</sup>. As with any quantitative biological measure, in anthropometric assessment it is important to minimize errors. Poor precision in measurement of an anthropometric variable will lead to underestimation of correlations with other variables<sup>5</sup>. The main sources of imprecision errors are random imperfections in the measuring instruments or in the measuring and recording techniques.

Although dietitians play an important role in the assessment of nutritional status<sup>6</sup>, including anthropometry, reports on anthropometric measurements made by dietitians rarely include estimates of measurement errors. Therefore, this brief report has the objective of estimating the degree of intraobserver precision for three common anthropometric measurements made by dietitians.

## Methods and Procedures

This study was conducted by twenty six dietitians (with narrow experience in anthropometric measures) after a period of theoretical orientation and practical experimentation of the different anthropometrical measurements. Each dietitian measured twice a sample of 10 volunteers (>20 years) of both genders who declared to be inactive. All individuals signed a free consent that included the procedures to be adopted and allowed the exploitation of the results found in scientific studies. The participants' privacy and anonymity were respected in the present study.

Each dietitian performed the following measurements: upper mid-arm circumference (MAC), tricipital skinfold (TS) and bicipital skinfold (BS). The measurements were made according to the method of International Society for the Advancement of Kinanthropometry<sup>7</sup>. Upper mid-arm circumference (MAC) was measured to the nearest 0.1 cm, using an anthropometric tape. Skinfold thicknesses (triceps and biceps) were measured to the nearest 0.2 mm using a Holtain skinfold callipers (Holtain Ltd. Crymych U.K.). All parameters were measured on the non-dominant arm.

To determine intraobserver precision, four different widely used precision estimates were calculated: the technical error of measurement (TEM), the relative technical error of measurement (rTEM), the coefficient of reliability (R) and the coefficient of variation (CV). The TEM is the most commonly used measure of precision, which is the square root of measurement error variance. TEM was calculated with the following formula<sup>4</sup>, where  $\sum d^2$  is the summation of deviations raised to the second power and N is the number of volunteers measured.

$$TEM = \sqrt{(\sum d^2)/2N}$$

The absolute TEM was transformed into relative TEM (rTEM) in order to obtain the error expressed as percentage corresponding to the total average of the variable to be analyzed. So, the following equation was used, where VAV is the variable average value (the arithmetic mean of the mean between both measurements obtained of each volunteer for the same anthropometrical measurement).

$$rTEM = (TEM / VAV) \times 100$$

The lower the TEM obtained, the better is the precision of the appraiser to perform the measurement. The standard adopted for the evaluation of the TEM found was the beginners' standard<sup>8</sup>. The acceptable maximum values were 7.5% from skinfolds and 1.5% from others measures as MAC.

The coefficient of reliability (R) was calculated as percentage with the following equation<sup>3</sup>, where  $SD^2$  is

the total intra-subject variance for the study, including measurement error.

$$R = 1 - \left( \frac{TEM^2}{SD^2} \right)$$

This coefficient shows the proportion of between-subject variance free from measurement error. Scores can range from 0 to 1, where a value of 0 indicates that all between-subject variation was due to measurement error and a value of 1 indicates that no measurement error was present. Thus, higher R values indicate greater measurement precision; we considered R values greater than 0.95 to be sufficiently precise<sup>3</sup>.

Finally, the coefficient of variation (CV) was calculated with the following formula, where  $\bar{X}$  is the average of measurements and SD is the standard deviation. The CV expresses sample variability relative to the mean of the sample.

$$CV = \frac{SD * 100}{\bar{X}}$$

The statistical analysis was performed with the software package SPSS (version 18.0; SPSS Inc, Chicago IL). The significance level was established as being less than or equal to 0.05.

## Results and discussion

The results of anthropometric measurements, TEM, rTEM and R values are present in table I. Measurements a and b were significantly different in all the evaluated parameters (MAC,  $P < 0.001$ ; TS,  $P < 0.05$  and BS,  $P < 0.05$ ). The results suggest that the precision to measure skinfold sites (tricipital and bicipital) was lower than the precision to measure MAC. Significant differences were registered between TEM for MAC and TEM for skinfolds ( $P < 0.001$ ). These results are consistent with those of previous reports<sup>9,10</sup>. Martine et al.<sup>9</sup>, for example, reported TEM values of 0.14 for MAC and 0.29 for TS.

In order to obtain the error value we used relative measure technical error (rTEM) which shows more precision for MAC than for skinfolds. These results are consistent with those of previous reports by Uli-

jaszek and Kerr<sup>3</sup>, those who did a comparison of studies that reveals that there is a clear hierarchy in precision of different nutritional anthropometric measurements and skinfolds normally are associated with largest measurement error.

The rTEM was higher for the BS than for TS and the rTEM for TS was higher than for MAC ( $P < 0.05$ ). The intra-observer rTEMs for circumference and skinfolds in our survey were lower to the reference values proposed by Gore et al.<sup>8</sup>. In all cases, intra-observer reliability was greater than 95%; these results are very similar to, or even better, than those observed by other investigators<sup>3</sup>.

Our results indicate acceptable variability in the precision of measurements of most measurements for all dietitians. Unacceptable values were only observed in the MAC for dietitians number 3 (rTEM=1.6) and number 5 (rTEM=2.4). The intra-observer variability presented acceptable results in all evaluators for the skinfolds analyzed. The results showed significant differences in the average of rTEM between three analyzed parameters, being the lowest value for the MAC, later for tricipital skinfold and finally for bicipital skinfold ( $P < 0.05$ ).

It is worth emphasizing that, despite results being acceptable for skinfold measurements, a higher variation on the rTEM was observed for BS than for TS. This result is not in accordance with other authors who found that the higher values for rTEMs in regions of higher fat accumulation, that is, higher for TS than for BS<sup>11</sup>. A possible cause of our results would be that dietitians are more acquainted with TS measurement than with BS, since tricipital is the most common skinfold thickness measures used to assess body fat.

Table II presents information on the mean ( $\bar{x}$ ), standard deviation (SD) and CVs for the three anthropometric measurements. SD for TS was higher than SD for BS, but after computation of the coefficient of variation, BS was a larger CV than TS (because the TS mean was so much larger than the BS mean). These results are consistent with the results obtained for rTEMs.

In conclusion, our results show an acceptable precision for anthropometric parameters evaluated, taking into account that the measurers were beginners. Additionally, results suggest that the precision to measure skinfolds was lower than the precision to measure the upper mid-arm circumference. And among the two skinfolds assessed, tricipital was measured with higher

**Table I**  
Anthropometric measurements, TEM, rTEM and R values

	a	b	d <sup>2</sup>	TEM	rTEM	R
MAC	26.7 ± 2.4	26.6 ± 2.4	0.6 ± 1.1	0.1 ± 0.1	0.6	0.997
TS	18.2 ± 4.3	18.4 ± 4.2	1.5 ± 2.6	0.2 ± 0.2	1.2	0.998
BS	10.5 ± 3.7	10.6 ± 3.8	1.7 ± 3.4	0.2 ± 0.2	2.2	0.997

MAC, upper mid-arm circumference; TS, tricipital skinfold; BS, bicipital skinfold; a, average of the first measurement; b, average of the second measurement; d, difference between the average; TEM, measure technical error; rTEM, relative technical error of measurement; R, coefficient of reliability.

**Table II**  
Average, standard deviation and coefficient of variation

	$\bar{X}$	SD	CV
MAC	26.6	2.4	9.0
TS	18.3	4.3	23.4
BS	10.6	3.7	35.4

$\bar{X}$ , average; SD, standard deviation; CV, coefficient of variation.

precision than bicipital. So, we recommend periodical training with the objective of controlling and minimizing the anthropometric measurement error.

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