IMPORTANCE OF STANDARDIZING THE PROTOCOLS USED TO ESTIMATE BODY FAT PERCENTAGE

Maria Júlia Ferreira e Silva4[1]
Rafael Ribeiro Alves1[2]
Nathan Muci Aguiar Damasio2[3]
Marcelo Henrique Silva1,**3**[4]

ABSTRACT

This study aimed to investigate the influence of the standardization of skinfold (SF) protocols on the assessment of body composition (BC) and to compare different methods for estimating body fat percentage (BF%). The sample included 16 men (age: 24.38 ± 1.43 years) whose SF measurements were obtained according to the ISAK (International Society for the Advancement of Kinanthropometry) protocol via a scientific adipometer. Seven BF% estimation protocols were compared via ANOVA for repeated measures, with Bonferroni post hoc correction. The results revealed significant differences between the protocols analyzed ($p < 0.05$), suggesting that the lack of standardization may compromise the accuracy of the evaluations. Therefore, maintaining the same protocol between the test and retest is essential to minimize variations in the results. Future studies should investigate the effects of standardization in more diverse populations, including children and adolescents.

Keywords: Body composition, skinfolds, predictive equations, body fat percentage.

IMPORTÂNCIA DE PADRONIZAR OS PROTOCOLOS UTILIZADOS PARA ESTIMAR PERCENTUAL DE GORDURA CORPORAL

RESUMO

Este estudo teve como objetivo investigar a influência da padronização de protocolos de dobras cutâneas (SF) na avaliação da composição corporal (CC) e comparar diferentes métodos de estimativa do percentual de gordura corporal (%GC). A amostra incluiu 16 homens (idade: 24,38 ± 1,43 anos) cujas medidas de SF foram obtidas de acordo com o protocolo ISAK (Sociedade Internacional de Cineantropometria Avançada) por meio de um adipômetro científico. Sete protocolos de estimativa do %GC foram comparados por meio de uma ANOVA de medidas repetidas, com correção post hoc de Bonferroni. Os resultados revelaram diferenças significativas entre os protocolos analisados ($p < 0,05$), sugerindo que a falta de padronização pode comprometer a precisão das avaliações. Portanto, manter o mesmo protocolo entre o teste e o reteste é essencial para minimizar as variações nos resultados. Estudos futuros devem investigar os efeitos da padronização em populações mais diversas, incluindo crianças e adolescentes.

Palavras-chave: Composição corporal, dobras cutâneas, equações preditivas, percentual de gordura.

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[1] Mário Palmério Center University, Monte Carmelo, Minas Gerais Brazil.
[2] College of Medicine, Federal University of Goiás, Goiânia, Brazil
[3] College of Physical Education and Dance, Federal University of Goiás, Goiânia, Brazil
[4] Uniaraguaia University Center, Goiânia, Goiás Brazil.

INTRODUCTION

Body composition (BC) can be measured via three different methods: direct, indirect, and dual indirect methods. The direct method consists of the dissection of a cadaver, in which the total body mass is separated by the structural components of the body. For indirect measurement, some equipment, such as densitometry and magnetic resonance imaging, is used to obtain more accurate evaluations, which have a high cost (Souza et al., 2014). Bioelectrical impedance and skinfold (SF) anthropometry are examples of dual indirect methods, which estimate body volume and require equations to convert it into measurements of fat mass and fat-free mass (Thomas et al., 2013).

Therefore, the evaluation of BC by SF measurements is considered a good alternative with affordable cost, as long as there is a standardization to mitigate errors among different evaluations, aiming to have minimal or no variability when it is applied by different evaluators or more than one time by the same evaluator. A good example of this variability is that a fold collected with only a 1 cm difference can produce significantly different results when measured in the same participant (Souza et al., 2014; Segheto et al., 2015; Böhme, 2000; Acland et al., 2012).

The International Society for the Advancement of Kinanthropometry (ISAK) has established a standard protocol for these anthropometric measurements (Acland et al., 2012), which are obtained by means of a calibrated caliper and always by the right hemibody. The individual must stand with the body upright and not tense, and the evaluator must highlight the SF with the skin and subcutaneous adipose tissue (without muscle tissue), namely, the triceps, subscapularis, biceps, iliac crest, supraspinale, abdomen, anterior thigh and medial calf. Each fold can be measured two or three times to obtain the average; however, it is recommended that there is no variation greater than 5% between them (Eston and Reilly, 2009).

According to the literature, female taekwondo athletes present significantly greater differences ($p \leq 0.01$) in SF thickness and fat percentage than male athletes do (Mekić et al., 2024), whereas elite soccer athletes also present significant differences ($p < 0.01$) in terms of anthropometry between different playing positions or with the use of different equations to estimate BC (Holway et al., 2024). Therefore, when choosing the equation, it should be considered that there are differences between populations and genders because when an equation is applied to a noncorresponding population, it loses its validity (Eston and Reilly, 2009).

On the basis of what the literature has elucidated about the importance of the standardization of BC predictive equations with SF, the form of measurement and the protocol to be used, the objective of this study is to compare different protocols for the evaluation of BC in men who have been untrained for at least 6 months, since nonstandardization can result in errors in diagnostic evaluations (formative and summative), thus compromising the results of each evaluation.

METHODS

Sample

Volunteers were invited through social networks (Instagram, Facebook) or through institutional communication (Google Classroom). The study included 16 male participants who had been untrained for at least 6 months. The characteristics of the volunteers (age = 24.38 ± 1.43 years; body mass = 75.1 ± 3.15 kg) are described as mean ± standard deviation in **Table 1.** All the participants were duly informed of the rules and procedures for performing the body composition test at the first visit. To assess general health status, the Physical *Activity Readiness Questionnaire* (PAR-Q) was used. All participants were informed about the protocol, and those who agreed to participate signed the informed consent form (ICF). All experimental protocols of the present study were submitted to the Ethics Committee of the Federal University of Goiás. CAAE: 56907716.5.0000.5083.

Table 1. Sample characterization.

Data	**Mean ± SD**
Age (years)	24.38 ± 1,43
Body mass (kg)	75.10 ± 3.15
Height (m)	1.75 ± 0.1
BMI (kg/m2)	23.87 ± 0.86
Estimation of body fat % based on different protocols	
BF % - Pollock ∑7 SF	14.90 ± 1.79
BF % - Pollock ∑3 SF	13.63 ± 1.74
BF % - Guedes ∑3 SF	16.95 ± 1.95
BF % - Petroski ∑4 SF	17.01 ± 1.63
BF % - Triceps SF (mm)	18.31 ± 2.00
BF - %Lean (WC)	16.44 ± 1.52
BF - %Lean (IMC)	17.88 ± 1.43

Results are presented as the mean and standard deviation (SD) – BMI = body mass index; BF = body fat; WC = waist circumference (cm).

Experimental Design

The study consisted of only two visits, which were separated by 48 to 72 hours. On the first visit, the volunteers completed the anamnesis and the informed consent form (ICF) and received written instructions on rules and procedures for performing the body composition test; on the second visit, with the instructions duly followed, the body composition of the volunteers was assessed.

Anthropometric assessment

Body mass (BM) was measured with a digital anthropometric scale, and height (h) was measured with a portable stadiometer attached to a flat wall. The body mass index (BMI) was calculated as the ratio between the BM and the square of the h (BMI = BM/h^2).

For the evaluation of perimetry, a nonflexible tape measure was used, and the following body segments were taken (thigh, leg, arm, forearm, waist, abdomen and hip). To assess body composition, skinfolds of the triceps (TRSF), subscapular (SSF), biceps (BISF), pectoralis (PTSD), middle axillary (MASF), suprailiac (SISF), supraspinale (SSSF), abdominal (ABSF), thigh (TSF) and medial leg (MLSF) points were taken according to the procedures presented by Luiz; Simões, (1996).

Table 2. Body density estimation formulas.

Jackson and Pollock 7 folds
Density = [1.112- 0.00043499 x (∑7 folds) + 0.00000055 x (∑ 7 folds)^2 - 0.00028826 x (age)]

Jackson and Pollock 3 folds for men
Density = 1.10938 – {0.0008267 x [(∑3 folds) + (0.0000016 x (∑3 folds) x (∑3 folds)] – (0.0002574 x age)]}
Guedes 3 folds for men
Density =1.17136-0.06706*LOG10 (∑3 ply)
Petroski 4 folds for men
Density = 1.10726863 - 0.00081201 x (∑4 folds) + 0.00000212 x $(\sum 4\ \text{folds})^2$ – (0.00041761 x age)
Lean; Have; Deurenberg, (1996)
BF % = [(1.33 x BMI) + (0.236 x Age)] – 20.2
Lean; He; Morrison, (1995)
BF% = [(0.567 x WC) + (0.101 x Age)] – 31.8
Triceps Skinfold
%GC = [(1,31 x TRSF) + (0,43 x Age)] – 9.16

BF = Body Fat; WC – Waist circumference; BMI – Body Mass Index; ∑ = Summary.

To perform the measurements, a scientific adipometer was used, with a precision of 0.1 mm, with the measurements performed in a rotational manner, always in the right hemibody, three times at each anatomical point, with the median value being noted. If there was a variation in the set of measures greater than 5%, new measures would be carried out to adapt the measures. From the measurements of the selected skinfolds, body density was estimated by models developed by Jackson and Pollock (1978) for men. For the estimation of the percentage of body fat, the Siri equation (1961) was adopted.

Table 3. Formula for estimating body composition from density according to Siri (1961).

%BF = [(4.95 ÷ density) – 4.50] x 100

BF = Body fat.

Statistical analysis

Repeated measures analysis of variance (ANOVA) was performed to compare the results between the seven different body fat % estimation protocols. When applicable, *Bonferroni post hoc* correction was used to identify differences between peers. A value of $p < 0.05$ was adopted for significant differences, and the results are shown in **Table 4.**

RESULTS

Repeated measures ANOVA revealed that there was a significant difference between the different protocols for measuring body fat %. (F [2.11, 31.73] = 6.51; p = 0.004; ηp^2 = 0.303). The data from the pairwise comparisons based on Bonferroni *post hoc correction* are described in **Table 4.**

When comparing the different estimation protocols, there was a significant difference between Petroski 4 folds and Pollock 7 folds and between Guedes 3 folds and Pollock 3 folds. As demonstrated in **Table 4.**

Table 4. Results of peer comparisons between the different protocols.

Factor	Comparison	D (%)	[IC95%]	p
Petroski ∑ 4 SF	Guedes ∑3 SF	0.54	[-1.90; 2.06]	= 1.000
	Pollock ∑3 SF	3.37	[0.83; 5.91]	= 0.004
	Pollock ∑7 SF	2.11	[0.09; 4.12]	= 0.035
	Lean (WC)	0.57	[-3.39; 4.53]	= 1.000
	Lean (BMI)	-0.87	[-5.13; 3.38]	= 1.000
	Triceps SF (mm)	-1.30	[-4.21; 1.60]	= 1.000
Guedes ∑3 SF	Pollock ∑3 SF	3.32	[1.38; 5.26]	< 0.001
	Pollock ∑7 SF	2.05	[0.42; 3.69]	= 0.007
	Lean (WC)	0.51	[-3.71; 3.56]	= 1.000
	Lean (BMI)	-0.92	[-5.42; 3.56]	= 1.000
	Triceps SF (mm)	-1.35	[-4.57; 1.85]	= 1.000
Pollock ∑3 SF	Pollock ∑7 SF	-1.26	[-2.62; 0.09]	= 0.084
	Lean (WC)	-2.80	[-5.73; 0.12]	= 0.068
	Lean (BMI)	-4.25	[-7.74; -0.75]	= 0.010
	Triceps SF (mm)	-4.68	[-8.13; -1.23]	= 0.004
Pollock ∑7 SF	Lean (WC)	-1.54	[-5.17; 2.08]	= 1.000
	Lean (BMI)	-2.98	[-7.05; 1.08]	= 0.361
	Triceps SF (mm)	-3.41	[-6.20; -0.62]	= 0.009
Lean (WC)	Lean (BMI)	-1.44	[-2.83; -0.06]	= 0.036
	Triceps SF (mm)	-1.87	[-6.74; 2.99]	= 1.000
Lean (BMI)	Triceps SF (mm)	-0.43	[-5.49; 4.62]	= 1.000

BMI = body mass index; WC = waist circumference; 95% CI = 95% confidence interval; p value obtained by ANOVA (analysis of variance).

DISCUSSION

Our findings reinforce the importance of standardization in relation to doubly indirect measurements for the estimation of body composition. When performing a peer comparison between the protocols of Petroski ∑ 4 SF, Guedes ∑3 SF, Pollock ∑3 SF, Pollock ∑7 SF, Lean (CC), Lean (IMC) and triceps SF, significant differences at eight comparison points were found.

The results presented by Da Silva; Silva; Medeiros (2017) of evaluations with women aged 26 ± 5.99 years and using 6 different protocols, reported no statistical differences between Lean BMI and Lean WC (p = 1.000), Petroski 4 folds and Pollock 3 folds (p = 0.389), and Guedes 3 folds and Pollock 3 folds (p = 0.689), which in our study were significantly different. However, few studies in the literature have compared these different evaluation protocols. Previous studies have highlighted that errors in evaluation can occur when different methods are used.

Although this study identified significant similarities between different assessment protocols, this does not imply that any of the protocols analyzed can be interchangeable. The sample was limited and consisted of a small group of untrained men, with a mean age of 24.38 ± 1.43 years and a body mass index (BMI) of 23.87 ± 0.86 kg/m². Therefore, future research should include larger samples and consider variables such as BMI, sex, and training status.

The assessment of body composition with accessible tools such as tape measure and scales reinforces the idea that the quality of the equipment should not be an impediment to carrying out physical assessments. Even without the use of high-cost materials or advanced software, it is possible to obtain significant and comparable results after interventions, even if these methods are not considered the gold standard or lack scientific validation.

On the basis of the current literature and the data obtained in this study, researchers and evaluators seeking greater accuracy in the assessment of body composition are as follows: 1) establish a standard for the measurement of skinfolds (Acland et al., 2012); 2) use the appropriate prediction equation for each population and ensure its maintenance during comparison measurements (Da Silva; Silva; Medeiros, 2017); and 3) consider the evaluator's experience, which is crucial for the accuracy of the results (De Souza; Pereira, 2019).

CONCLUSION

Therefore, it is possible to conclude that, in addition to the evaluator's experience, maintaining the same body composition estimation protocol between the test and retest is necessary. After all, the significant difference found between individuals when there is a change in protocol can be a confounding factor when evaluating the results of the intervention, whether it is diet, exercise or a combination of both. Future studies need to be conducted with children and adolescents to clarify the need for standardized protocols in different populations.

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