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point-of-view

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A century of skinfolds for body composition estimation: what we learned?

Um século das dobras cutâneas para estimativa da composição corporal: o que aprendemos?

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Abstract – In 2021, we reached the centenary of the creation of the first body composition assessment model based on the use of skinfolds. A hundred years after Matiegka's application in 1921 to the analysis of "human efficiency", this point of view study seeks to bring reflections on the continuous applicability of the method, historical points, relevant advances, and possible projections for the future. Indeed, the comparability of skinfolds with multicompartmental reference methods shows several advantages and disadvantages; if on the one hand we have low cost, speed, and reproducibility, on the other hand we have problems associated with the quality of the equipment, the evaluator's skill and mainly the adequate choice of the predictive model. Thus, when it comes to the assessment of body composition, skinfolds are still a good option for application in different contexts by health professionals as long as the evaluator pays attention to the critical aspects that may represent sources of errors (for example, the level of training/experience, correct skinfold location). Even with the numerous advances in the area, there is solidity and continuity for the application of skinfolds for the future.

Key words: Body composition; Kinanthropometry; Skinfold thickness.

Resumo – *No ano de 2021 chegamos ao centenário da criação do primeiro modelo de avaliação da composição corporal a partir do uso de dobras cutâneas. Passado cem anos da aplicação por Matiegka em 1921 para análise da "eficiência humana", esse estudo de ponto de vista busca trazer reflexões sobre a contínua aplicabilidade do método, pontos históricos, avanços relevantes e possíveis projeções para o futuro. De fato, a comparabilidade das dobras cutâneas com métodos de referência multicompartimanentais mostra diversas vantagens e desvantagens; se por um lado temos o baixo custo, rapidez, reprodutibilidade, por outro lado temos problemas associados a qualidade do equipamento, habilidade do avaliador e principalmente a escolha adequada do modelo preditivo. Deste modo, em se tratando de avaliação da composição corporal, as dobras cutâneas continuam sendo uma boa opção de aplicação em diferentes contextos por profissionais da saúde desde que o avaliador se atente aos aspectos críticos que podem representar fontes de erros (por exemplo o nível de treinamento/experiência, local correto da prega cutâneas). Mesmo com os inúmeros avanços da área, percebe-se uma solidez e continuidade para a aplicação das dobras cutâneas para o futuro.*

Palavras-chave: *Composição corporal; Cineantropometria; Dobras cutâneas.*

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INTRODUCTION

In a world that was recovering from the First World War, the year 1921 was a milestone for the study of body composition. In that year, there was the first publication of a model to estimate "physical efficiency" from skinfold thickness[1]. The classical study completed a centenary in 2021, which proposed a model of anatomical-tissue fractionation of body mass in skin-plus-subcutaneous adipose, skeletal muscle, bone remaining and residual tissues. Nevertheless, it is convenient to reflect on the historical context of the use of skinfold thickness.

Over the last century, different methods have been proposed to quantify and characterize body composition: surface anthropometry, bioelectrical impedance, ultrasonography, air-displacement plethysmography, dual energy X-ray absorptiometry (DXA), computed tomography and magnetic resonance imaging[2]. To choose a method, not only repeatability, reproducibility and reliability must be considered, but also the feasibility of application in each intervention scenario.

In regard, the use of skinfold thickness is a non-invasive tool with satisfactory reliability and operability to estimate body composition. However, the method still has several unresolved limitations, for example, intra- and inter-evaluator measurement variability and the inappropriate reproduction/use of predictive mathematical models[3].

Thus, this brief point of view aims to reflect on the applicability of skinfold thickness and predictive mathematical models of body composition in the last century, highlighting the historical context, relevant advances, and thematic projections.

SKINFOLD THICKNESS AND ESTIMATION OF BODY COMPOSITION

The interest in the assessment of body composition, initially explored with the objective of qualifying a person to work in the industry[1], increased its applicability with studies that showed an association with cardiovascular disease, diabetes, cancer, osteoporosis, among others[4]. In addition, recent studies have shown the relationship between a patient's body composition as an important variable for clinical decision-making associated with immune functioning, length of hospital stay, morbidity and mortality[5].

A classic study with a sample of human cadavers observed that approximately 80% of the adipose tissue is deposited subcutaneously[6]. Additionally, a close statistical relationship was observed between the skinfold thickness measured with a caliper and the thickness of the subcutaneous tissue measured directly with an incision[6]. Therefore, skinfold thickness are satisfactorily valid as independent variables in the estimation of body adiposity.

Matiegka[1] has established specific anatomical sites for measuring subcutaneous adipose tissue: upper arm (above biceps), forearm (maximum breadth), thigh (mid-point of the anterior surface), calf, thorax (on the costal margin) and abdomen (mid-point between iliac spine and navel). After a century, the sites described in 1921 are continually reproduced. There are currently dozens of sites susceptible to measurement of skinfold thickness[7]. However, the inaccuracy of the site marking is an important source of technical error in intra-evaluator measurement[8].

To overcome these limitations, over the decades, global efforts have been made to improve scientific research in the anthropometric scope and the consequent more appropriate use of skinfold thickness. Several technical standardizations of anthropometric measurement are documented in the literature[9,10]. However, the variety of published references is understood as a systematic error matrix, as it makes it difficult to select the guideline that will be used and minimizes the degree of reproducibility of inter-evaluator measure. In addition, the main references of classical literature were published in book chapters[11], which have not been revised and/or updated and access is limited mainly in Latin American countries.

In 1978, the International Council for Sport Science and Physical Education (ICSSPE) met in Brazil and created the International Working Groupon Kinanthropometry (IWGK), spreading kinanthropometry as a scientific discipline until the establishment of the International Society for the Advancement of Kinanthropometry (ISAK) in 1986. This association aims to create an international network of anthropometrists, regularly updated in the practical and scientific perspective in anthropometric measurement of excellence, based on a hierarchical accreditation scheme recognized worldwide[12]. This was an important step towards the correct application of the method, not only due to standardization, but also because of the training offered to professionals in the field.

SKINFOLD THICKNESS AND MATHEMATICAL MODELS

It is widely accepted that skinfolds thickness can provide an adequate estimation of body composition[13]. There are hundreds of original studies proposing developed and validated mathematical models to estimate the chemical-molecular or anatomic-tissue component of body adiposity for different ethnicities, age groups, levels of physical activity and/or adverse health conditions such as obesity[14]. These mathematical models are defined as property-based techniques and are classified by functionality derived from statistical analysis of quantitative measures or incorporating relatively constant proportions. However, it is necessary to know that the conversion of skinfolds thickness into relative adiposity is based on hypotheses of physical and biological constancy, which considerably reduces the degree of reliability of estimates[3].

Considering the morphological and demographic specificity of the population samples investigated in the original studies, it is essential to carefully choose the ideal mathematical model to be used in the intervention scenario. In addition, every year dozens of new regression models for estimating body adiposity are presented to healthcare professionals. However, the scarcity of validation studies remains, as well as their indiscriminate application in different populations. This is another important consideration to make about the method, even a century after the first application.

SKINFOLDS THICKNESS AND EXPECTATIONS FOR THE COMING YEARS

In 2021, a review study was conducted to evaluate the best tools for assessing body composition in athletes. Interestingly, even with the perception of the increased use of more advanced techniques such as DXA, the need for simplicity, practicality and quick evidence for decision making indicates skinfolds as the preferred method[3].

Thus, even after a century of using skinfolds originally created for the estimation of "physical efficiency" by Matiegka, 1921, the use of the method continues to meet the needs of anthropometry. Nickerson's study showed that the skinfold method has adequate precision for assessing body composition when compared to four-compartment (4C) models[13].

Additionally, another discussion concerning skinfold thickness is related to the classification-anthropometry only as a double-indirect method. A multicompartmental mathematical model proposed for anatomical-tissue estimation, developed with direct analysis in cadaver samples based on the proportionality strategy, taking a unisexual human metaphorical reference, the *Phantom*. Thus, from a theoretical point of view, it is configured as an indirect technique. However, after three decades, there is a shortage of complementary studies that investigate its cross-validation, mainly in Latin American population samples.

As perspectives, it is also worth mentioning that the use of absolute values and the respective percentiles seems to be a valid strategy, to the detriment of the high number of mathematical models to estimate relative and/or absolute body adiposity from skinfold thickness. The percentiles represent information that would help establish graphs to be used as a risk identification tool in each population without the intrinsic error of regression statistics.

FINAL COMMENTS

Finally, bi and/or multicompartmental mathematical models are not the only way to diagnose and/or control the components of body adiposity. The applicability of skinfold thickness is wide. They can be used to estimate the magnitude of the endomorph component of human somatotyping in the anthropometric approach. Furthermore, the absolute value of the skinfold thickness, expressed in millimeters, is an important tool to determine the approximate local, regional or subtotal amount of skin-plus-subcutaneous adipose tissue. The monitoring can be performed out by comparing intra-individual measures or using standard scores and/or percentiles curves for a single skinfold or the sum of them across different anatomical sites. Additionally, the adipose and musculoskeletal areas of limbs, estimated from girths corrected by corresponding skinfold thickness, have been shown to be reliable indicators of the metabolic-energetic state and soft tissue responsiveness in dietary, pharmacological and/or physical performance interventions. In summary, the crossing of two or more information from these pathways' conditions an effective assessment.

A century after the publication of Matiegka's classic study, we pointed out that the skinfold method still holds promise for use by different professionals in different contexts, be they clinical, sports, or even hospital settings. However, we also point out aspects that remain relevant and should be observed in the use of the method, such as: evaluator training, correct identification of the site, proper use of the choice of the regression model and the possibility of applying values in the form of percentiles.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

This article did not use data collected from humans and represents a scientific opinion of literature. This research is in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: WLR, JHCA and LU. Performed the experiments: WLR, JHCA and LU. Analyzed the data: WLR, JHCA and LU. Contributed reagents/materials/analysis tools: WLR, JHCA and LU. Wrote the paper: WLR, JHCA and LU. All authors read and approved the final version of the manuscript

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