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Review Paper

Comparison of methods to measure body fat in 7-to-10-year-old children: a systematic review

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ABSTRACT

Objective: To investigate methodological aspects in body fat (BF) measurements in 7-to-10-year-old children.

Study design: Systematic review of the literature.

Methods: The studies were chosen from the PubMed and Scielo databases according to a protocol that defined: inclusion criteria; a search and quality-assessment strategy; and information extraction.

Results: 27 studies published from 2004 to 2014 were included. The literature describes skinfold measurements and dual energy X-ray absorptiometry (DEXA) as being the reference methods most widely used in the assessment of the ability of methods to identify BF. The most commonly-used statistical analyses were the Pearson correlation coefficient, and sensitivity and specificity performance analyses. The comparison between the tested methods and the references showed that body mass index (BMI) and waist circumference (WC) are strongly correlated to BF as calculated by bioelectrical impedance or skinfolds, and that there is a moderate positive correlation with percent body fat as calculated by DEXA, air-displacement plethysmography (ADP) or isotope dilution. There was a moderate positive correlation between weight-to-height ratio (WtHR) and BF, as estimated by ADP and skinfolds. Performance studies suggest that BMI and WC are very specific but less sensitive methods.

Conclusions: The results of this systematic review show favourable evidence for the use of anthropometric indicators – above all BMI and WC– in the measurement of BF, when more accurate techniques such as DEXA and ADP are not feasible. They also demonstrate features that make them advantageous for epidemiological studies in a child population, since they are easy and safe to obtain and well tolerated by the children.

Introduction

Obesity is an important risk factor for cardiovascular diseases, type-2 diabetes, hypertension and cancer,[1] and when it occurs in infancy it increases the likelihood of these diseases in adult life.[2,3] Early evaluation of nutritional status therefore becomes important, since it enables interventions that can prevent and control obesity and overweight-associated diseases.[4]

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Evaluation of body fat (BF) in children may be performed by techniques that provide valid estimates of body composition, such as dual X-ray absorptiometry (DEXA), isotope dilution and air-displacement plethysmography (ADP).[5] However, other measurement methods are more feasible in epidemiological studies, including skinfolds and bioelectrical impedance (BIA).[6]

Anthropometric measurements and indicators are also present in epidemiological studies, such as waist circumference (WC) and body mass index (BMI), defined as the body mass (kg) divided by the square of the height (m^2).[7] The measurement method for BF must not only be valid and reliable, but also be easily-obtained and easy to interpret. However, for children, there are difficulties in identifying the method to be used, given the profusion of studies on the topic, involving different measurements and statistical analyses. Therefore, this study aims to investigate methodological aspects in body fat (BF) measurements in 7-to-10-year-old children.

Methods

The studies were chosen according to a protocol that defined: inclusion criteria; a search and quality-assessment strategy; and information extraction. For a study to be included, it needed to have addressed the comparison of BF evaluation methods in 7-to-10-year-old children, as shown in Fig. 1. Bibliographical data were searched for in the PubMed/Medline and Scielo databases using a specific strategy defined in sentences made up of keywords based on the features of interest. An example is presented in PubMed (Fig. 2) of the search results.

The parameters of the search were defined as the period (January 2003 to August 2014) and the languages (English, Spanish and Portuguese). Despite the use of Boolean operators to extend or restrict the number of studies identified, it was impossible only to include studies that presented the features of interest. For the first listing obtained ($N_0 = 1770$ articles) a further selection had to be carried out on the basis of a reading of the titles. This led to the identification of $N_1 = 107$ studies as eligible, after an analysis of the abstracts carried out independently by two evaluators. They decided upon the eligibility of the studies based on the features of interest (Fig. 1). The decision was made by consensus whenever there was a dissenting opinion about the inclusion of a study.

We followed PRISMA guidelines to conduct this review. The methodological quality and risk of bias of eligible studies ($N_2 = 54$) were assessed by reading them in their entirety and constructing a score according to Downs and Black (1998).[8] Since the aim of the study was to compare methods, we opted to use 11 questions out of a total of 27 in the original instrument. In this systematic review, we decided arbitrarily that we would include articles with a final score equal to or above eight points, corresponding to the 3rd quartile (Q3) of the score, as an indication of methodological quality.

For articles presenting methodological quality ($N_3 = 27$), two researchers extracted the data concerning the purpose of the study; population studied; sample size; and study design. Other variables related to BF-measuring methodology were extracted, such as type of method and the device manufacturer, body sites for the skinfold and waist circumference measurements, methods taken as reference; methods used for statistical analysis and outcomes of interest. Fig. 3 shows the flow chart of the study selection.

Results

The methodological characteristics and main results of the studies are given in Table 1. The articles were published between 2004 and 2014 and the participants' ages ranged from 5 to 19 years. The sample sizes ranged from 30 to 8269 participants. In all, eight studies (29.6%) were conducted in Europe, seven (25.9%) in Asia, four in North America (14.8%), four in South America (14.8%), two in Africa (7.4%) and two in Oceania (7.4%).

It was found that BMI was used in 78% of the studies ($n = 21$), and its performance was tested against methods such as ADP, DEXA, BIA and skinfolds. The performance of WC was investigated in nine studies, followed by weight-to-height ratio (WtHR) ($n = 5$), BIA ($n = 5$), skinfolds ($n = 3$), waist to hip ratio ($n = 3$), hip circumference ($n = 1$), neck circumference ($n = 1$), Rohrer's index[a] ($n = 1$), conicity index[b] ($n = 1$) and arm fat area ($n = 1$).

The most commonly used techniques for estimating BF in children were skinfolds ($n = 10$) and DEXA ($n = 8$). BIA ($n = 6$), isotope dilution ($n = 3$), BMI ($n = 3$) and ADP ($n = 2$) were also taken as reference methods.

The most commonly used reference system for the classification of obesity based on BMI was that of the *International Obesity Task Force* – IOTF-2000[9] ($n = 10$; 37.0%), followed by the CDC-2000[10] curves in eight articles (29.6%). Four (14.8%) used the OMS-2007[11] curves, while the others (18.5%) took into consideration the reference curves of the countries where they were carried out: in two cases,[12,13] Conde and Monteiro-2006 curves were used.[14]

The most commonly used skinfold sites were the triceps ($n = 14$ studies) and subscapular ($n = 13$), followed by the iliac crest ($n = 5$), biceps ($n = 3$), thigh ($n = 2$) and calf ($n = 2$). One study used the abdominal skinfold. Researchers mostly worked by inserting skinfold values into predictive equations, particularly that of Slaughter et al. (1988)[15] ($n = 9$).

Repeated measurements were described in 11 articles: in six articles they were obtained in duplicate, in four they were obtained in triplicate, and in one study they were obtained four times. In three of the studies that used duplicate measurements, a third measurement was carried out whenever the values differed by more than 1 mm[13] or 2 mm.[16,17] Another study mentions this procedure but does not explicitly state the criterion of proximity between values measured.[18]

The most commonly used skinfold calliper was the Harpenden® ($n = 7$), followed by the Holtain® ($n = 3$), Lange® ($n = 3$) and Cescorf® ($n = 1$). Eleven studies stated which side of the child's body the measurements were taken from: six on the right and five on the left.

[a] Rohrer's index = weight (kg)/stature $(m)^3$.

[b] Conicity index = waist circumference (cm)/ $0.109 \times \sqrt{weight(kg)/stature(m)}$.

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