Diagnosis of child and adolescent nutritional status

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Abstract

Objective: to present a review on the methods for the assessment of child and adolescent nutritional status, emphasizing anthropometry and the various methods for the assessment of body composition; pointing out their advantages, limitations and risks.

Methods: chapters of textbooks, theses, and articles relevant to the topic, as well as personal files and authors previous publications were selected.

Results: anthropometry, which consists of the assessment of physical dimensions and global composition of the human body, has been regarded as the most frequently used isolated method for nutritional diagnosis, especially in childhood and adolescence, due to its ease of use, low cost and innocuousness. The most frequently adopted measurements aim at determining body mass, expressed by weight; linear dimensions, especially height; body composition and reserves of energy and proteins, estimated through subcutaneous fat and muscle mass. Laboratorial methods especially developed for the assessment of body composition are presented here. The justification for the use of methods that expose children and adolescents to ionizing radiation is also presented.

Conclusions: on defining methods for the assessment of nutritional status, we should select those that better detect the nutritional deficiencies we want to correct, also taking into consideration their costs, level of personal skill required for their proper application, necessary time for application, acceptability by the studied population and possible health risks.


Introduction

The assessment of nutritional status aims at checking growth and body ratios of an individual or community, thus allowing the implementation of intervention actions. This way, it is of paramount importance that there be a standardization of assessment methods to be used for each age group, bringing the criteria employed by health professionals into uniformity.

When defining assessment methods for nutritional status, those which better detect nutritional problems to be corrected in the study population should be prioritized. In addition, it is necessary to take into consideration costs, level of personal skills required to apply such methods, time necessary for their implementation, acceptance of the method by the study population as well as possible health risks.

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Anthropometry, which is concerned with the assessment of physical dimensions and total body composition, has been considered, isolatedly, the most used method for nutritional diagnosis in populations, especially in infants or children, and adolescents. Anthropometric measures are easy to use, low-priced, and harmless. Anthropometry as a method for nutritional status assessment was systematized by means of Jelliffe’s publications, edited by the World Health Organization in the 60’s, which, in their turn, were based on studies carried out in the 50’s. Thanks to these studies, anthropometry started to develop at an accelerated pace in industrialized countries. Such development only reached developing countries in the mid-70’s. Since then, anthropometry has evolved on a regular basis and is currently used for populational, clinical and intervention studies; its implementation enabled advancements as to interpreting and searching for mathematical formulations that improve the accuracy of body ratio estimates and their predictive power.1

Anthropometric values represent, at an individual or populational level, the degree of adjustment between genetic growth potential and environmental factors that are favorable and harmful. The ideal anthropometric standard is that obtained from populations or ethnic groups whose individuals are able to develop their growth potential to the fullest. Therefore, the statistical results obtained in industrialized or underdeveloped regions of the world from upper socioeconomic level populations, who probably had better chances to meet their genotypical growth potentials. Results of studies carried out all over the world have shown the possibility of using a single, international reference to assess growth and nutritional status in different regions. There is some evidence that height and weight gain in healthy children of different ethnic descents, submitted to adequate living conditions, is similar up to the fifth year of age. Taking this into consideration, the World Health Organization adopted the National Center for Health Statistics (NCHS) as international reference standard in 1978. In 1995, however, a new debate was initiated on the need for building up a growth curve for infants and adolescents, involving some aspects such as breast-feeding (NCHS infants were formula-fed), inclusion of other anthropometric indicators, use of data from other countries (not only from the USA), among others.3 The World Health Organization has been working hard towards the creation of new growth patterns, whose data are already being collected in different continents from exclusively breast-fed infants until, at least, the fourth month, and under complementary feeding until, at least, the first year of life.4

There are a number of methods for assessing body measures, but those which are easy to use, quick, reproducible and harmless should be preferred, as they allow maximum information about the nutritional problem under investigation. The most frequently used measures have the objective of determining body mass, indicated by weight; linear dimensions, especially height; body composition and energy and protein reserves, estimated by major superficial soft tissues: subcutaneous fat and muscle mass.5

Anthropometry, even with its limitations, has been the most universally used method and also the most recommended by the World Health Organization.3 The downside of this method is that, isolatedly, it does not identify specific deficiencies such as hypovitaminosis A, iron deficiency anemia and calcium deficiency, children’s and adolescents’ low-nutrient diets.6,9 In these situations, complementary exams are necessary for a conclusive diagnosis.

Biochemical methods usually depend on blood and urine samples to assess specific nutritional deficiencies. These methods have some limitations as to their use, because they more invasive and costly, and should be carefully used for conclusive diagnosis or therapeutic or intervention purposes.10

The clinical examination is based on checking the signs of external epithelial tissues such as skin, eyes, hair and buccal mucosa, which are associated with inadequate nutrition.5 This examination is practical, easy to use and inexpensive, but its use has been restricted in the last few years due to the validation of other methods.10 This method also presents some disadvantages, namely: difficult quantification and comparison of data, reduced specificity and sensitivity, especially because the clinical signs of malnutrition can only be observed when deficiency is at an advanced stage.5,11

Surveys into family or personal food consumption are indirect indicators of nutritional status; nutritional status is not only determined by food intake but also by physical activity and presence of acute or chronic diseases. The information obtained from the surveys into food consumption are important to help detect specific dietary deficiencies, and also guide dietary supplementation programs. The study of eating habits and kinds of food ingested are of inestimable worth for redefining nutritional education actions.12

Assessment of child nutritional status

Growth assessment is the measure that best defines infants’ health and nutritional status, since health and nutrition disorders invariably affect child growth, regardless of their etiology. In developing countries, most health and nutrition problems in childhood are associated with inadequate food intake and recurrent infections. These two conditions are closely related to population’s standard of living, including food, housing and health care. Thus, child growth assessment is an indirect way to measure population’s quality of life. Therefore, several studies have been conducted in order to check infants’ nutritional status. The World Health Organization has gathered 79 national surveys carried out between 1980 and 1992 in developing countries in Africa, Asia and Latin America, covering 87% of the total
population of infants under 5 years, with the aim of evaluating the prevalence of protein-energy malnutrition based on infants’ weight and height data. It was observed that decreased height is more common in developing countries as a whole, affecting 43% of children at preschool age; the prevalence of weight deficiencies is still high, especially in Africa and Asia.  

In Brazil, two large surveys were carried out using anthropometric data in representative samples of Brazilian infants and adults. One of these surveys, conducted in 1974, was the so-called National Survey into Family Expenses; the other was called National Research on Health and Nutrition, in 1989. Monteiro et al., in 1995, when studying the data obtained from these two national surveys, found a reduced rate of malnutrition among infants and adults and, on the other hand, an elevated prevalence of obesity among adults and stabilized obesity among infants.  

According to results obtained by the National Research on Health and Nutrition, 31% of Brazilian infants, younger than 5 years, presented some kind of malnutrition. The most frequent deficiency was revealed by the height/age ratio, indicating the predominance of chronic malnutrition. The prevalence rates for obesity in children younger than 10 years were between 2.5% and 8% in high-income and low-income families, respectively.  

The anthropometric parameters usually employed for assessing infants’ or children’s nutritional status are weight and stature (height or length). Head, thoracic, brachial and abdominal circumferences may be used. The values of these anthropometric data should always be assessed in relation to infants’ age and gender, which are the major determinants of their evolution. Although these procedures are usual and simple, they should be applied carefully, through standards; in addition, the tools should be regularly calibrated.  

The three widely used anthropometric indices (weight for age, height for age, weight for height) may be calculated through the measurement of weight and height. The involvement of the height for age index indicates that child growth is affected on the long run (stunting). The deficiency in the weight for height index shows a more recent involvement of growth with strong reflection on weight (wasting).  

To draw a comparison between a set of anthropometric measures and a reference standard, several scales may be used. The most common scales are the percentile and the Z score.  

Z escore means, in practice, the number of standard deviations that the obtained data are dispersed from the reference mean of the distribution.  

Percentiles derive from the distribution in increasing order from the values of a parameter, observed in a given age or gender; the classification of infants into a given percentile allows the estimation of how many infants, the same age and gender, are taller or shorter in relation to the assessed parameter.  

Growth follow-up through the growth graph-curve in at least three weight and height successive measurements, at intervals compatible with the growth rate in relation to age, allows us to check whether children are entering a malnutrition process, with a tendency towards growth pattern distancing (lower percentiles). This tool is extremely useful for identifying situations in which there is nutritional risk.  

When the growth of preterm babies and/or babies with low height for their gestational age needs to be assessed, it is important to consider that, if the same standards are used, these infants are likely to stay, during several months, below the acceptable levels for full-term babies, with adequate weight. Therefore, it is recommendable to use proper growth tables and curves for this group, at least up to 24 months, when the preterm group reaches values that are similar to full-term babies.  

The most commonly used and long-standing anthropometric classifications are: Gomez classification system (modified by Bengoa), Waterlow classification system (modified by Batista) and that of the World Health Organization.  

### Gomez classification system  

The system proposed by Gomez was designed to determine the prognostics of morbi-mortality of infants admitted to hospital according to their nutrition status. However, this criterion began to be used as a nutritional classification system. Despite criticism, this system, due to its simplicity, has been used in several countries, especially in Latin America. This classification system is preconized for infants younger than 2 years (Table 1). At this age, weight is the parameter that presents the highest growth rate, and the variation is much more related to age than to length. This makes the weight parameter more susceptible to nutritional problems, and consequently, it is the first parameter that goes through alterations.  

This system is based upon weight-for-age and gender.  

\[
\frac{\text{observed weight}}{\text{expected weight for age and gender (p50)}} = (p50) - \text{NCHS reference standard 50th percentile}
\]

### Table 1 - Nutritional status according to Gomez classification system (modified by Bengoa)  

<table>
<thead>
<tr>
<th>Weight/age</th>
<th>Nutritional status</th>
</tr>
</thead>
<tbody>
<tr>
<td>adequation%</td>
<td></td>
</tr>
<tr>
<td>91-110</td>
<td>Eutrophy</td>
</tr>
<tr>
<td>76-90</td>
<td>Mild or 1° degree malnutrition</td>
</tr>
<tr>
<td>61-75</td>
<td>Moderate or 2° degree malnutrition</td>
</tr>
<tr>
<td>≤60</td>
<td>Severe or 3° degree malnutrition*</td>
</tr>
</tbody>
</table>

* In the presence of comprovadamente nutritional edema, regardless of weight-for-age, the infant will be regarded as having 3° degree malnutrition (Bengoa).
**Waterlow classification system**

Proposed in 1973, it allows intervention prioritization as it established the type of malnutrition.

This system is based upon height-for-age and weight-for-height, and is preconized for infants between 2 and 10 years. At this age, growth is slower and constant; height is predominant; therefore, infants’ weight varies according to height instead of age. Consequently, nutritional problems will be better assessed through the height-for-age, followed by weight-for-height.

- **observed height**
  - height expected for age and sex (p50)

- **observed weight**
  - weight expected for observed height

**Eutrophy:** H/A higher than 95% and W/H higher than 90% of the 50th percentile;

**Wasted:** H/A higher than 95% and W/H less than 90% of the 50th percentile;

**Wasted and stunted:** H/A less than 95% and W/H less than 90% of the 50th percentile;

**Stunted:** H/A less than 95% and W/H higher than 90% of the 50th percentile.

**World Health Organization classification**

This classification may be used for infants regardless of their age. The Z-score values for the classification of Protein-Energy Malnutrition are presented in Table 2.

<table>
<thead>
<tr>
<th>Protein-energy malnutrition</th>
<th>Height/age Z Escore</th>
<th>Weight/height Z Escore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>-2 —</td>
<td>-3</td>
</tr>
<tr>
<td>Severe</td>
<td>Less than -3</td>
<td>Less than -3</td>
</tr>
<tr>
<td>(severe stunting)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

—|-: including

measurement (infant) – reference median

Standard deviation (for age and gender)

The World Health Organization regards infants as undernourished when their indices are less than -2 Z scores below the reference median. Infants below -3 Z scores or less than 70% of adequation in relation to the median, or in the presence of nutritional edema, are classified as having severe malnutrition.¹⁸

This classification is not suitable for primary assistance, since it identifies only the moderate and severe forms of malnutrition, which prevents an early intervention in infants who present mild forms of the disease or who are at risk of malnutrition.

Douek and Leone compared the classification systems proposed by Gomez, Waterlow and the World Health Organization for the assessment of the nutritional status of infants up to the age of 2. They found out that Gomez classification system proved to be the best, since its use for the routine assessment of infants up to 24 months is more valid as it presents less error probability than the other two systems when classifying infants as undernourished or healthy. On the other hand, it is advisable that Gomez classification system be used with extra care on younger children, since its error margin is higher in the first year of life due to the probability of a false positive diagnosis; in other words, classifying a normal child as having protein-energy malnutrition.¹⁹

Therefore, in the first three months of life, it is recommendable to take into consideration the clinical aspect, vitality, movement, urine and evacuation frequency and sleep pattern in order to assess the nutritional status. At this stage, the average weight gain is normally around 30 g/day. If weight gain is less than or equals 20 g/day, a situation of nutritional risk is established.

Victora et al., due to little variation presented by Brazilian studies on the prevalence of weight/height deficiency, and its low rates in children up to five years, found out that it is possible to estimate height deficiencies by means of weight deficiency, as there is a strong correlation between these two indices. The objective is to simplify nutrition assessments in communities where height or length measurements are harder to obtain, enhancing the coverage of nutritional surveillance systems.²⁰

Almeida et al. evaluated the use of the 10th percentile for weight/age as cutoff point for the detection of infants up to 60 months at risk for malnutrition, in comparison to Z-score (above or below -2) especially for food supplementation programs. They concluded that the use of this percentile is adequate for screening infants with weight/age and weight/height deficiencies since it has high sensitivity. However, due to its low specificity, these infants have to be better evaluated later.²¹

To assess the impact of nutrition rehabilitation and food supplementation programs, the use of the Z-score increment on the three indices is more sensitive, allowing infant development to be assessed.²²²⁴
As to obesity in infants, the following criteria may be used: weight/height ratio higher than or the same as 120%; percentile higher than or the same as 97 or Z-score higher than or the same as +2,0.25

The assessment of body composition is hard to be obtained in infants due its constant variation throughout the growth stage; in addition, the body fat content that increases health risks is not known. This kind of assessment is mainly recommended for checking alterations presented by infants who are undergoing an antiobesity therapy.26

**Assessment of nutritional status in adolescents**

Adolescence comprises the period between 10 and 19 years according to the criterion adopted by the World Health Organization.3 This period is characterized by profound biopsychosocial changes and this is the time when teenagers start to define their personality and establish a system of personal values, showing vulnerability to the problems most societies are faced up with today.27

The biological changes that occur through hormone actions during adolescence determine puberty. Marshall uses this term to designate all the morphological and physiological changes that occur in teenagers, establishing the transition from childhood to adulthood. These changes are characterized by changes in weight, height, body composition, physiological changes in internal organs with the development of central circulatory and respiratory system and bone growth.28 These changes occur at different paces and proportions among individuals of the same or different sex; however, the order in which these events take place is relatively the same.29

Several factors are associated with the growth process and sexual maturity. Genetic factors are mostly in charge of individual variation of pubertal phenomena. Genetic potential is maximized in adolescents through favorable environmental factors, and nutrition plays a vital role in this process.30

Approximately 50% of the weight and 20-25% of the height of an individual are built during adolescence, and nutrition at populational level serves as a highly significant indicator of variability in this process.31,32 The secretion of gonadal hormones may be inhibited by insufficient amount of nutrients, causing retarded onset of pubertal development, which may compromise gain of height.33 Therefore, it is important to follow up the growth and development of adolescents in order to guide actions in this age group.

A great part of validity studies on nutrition assessment tools and establishment of cutoff points for nutritional status classification in adolescents is mainly concerned with reaching a consensus as to the diagnosis of obesity.34-40 This concern is justifiable since there is a worldwide increased prevalence of obesity and potential risks for the development of chronic diseases in adulthood.3,41-43

In Brazil, data obtained from the National Survey into Health and Nutrition in 1989, through anthropometric parameters, show a prevalence of overweight of 7.6% among adolescents, with a higher prevalence among females (10.5%).44

Anthropometric measurements such as weight, height, circumference and skinfold thickness, expressed in percentiles or Z-scores,3 have been widely used for assessing nutritional status in adolescents. When interpreting the data obtained from nutritional assessment is essential to take the criteria of sexual maturation into consideration since chronological age has secondary importance at this time due to enhanced individual variability in the maturation process.45

The weight/age ratio is a current nutritional status parameter, and although measurements are easily obtained, it does not distinguish between current malnutrition and previous malnutrition. It should be observed that during the pubertal stage, hormonal interactions influence the variability of pubertal development as to its duration, sexual maturation rate, ponderal index and body composition between genders, limiting the use of the weight/age ratio. This indicator provides restricted information on body composition, and its correlation coefficient declines in puberty, losing its value.46 This indicator is more useful for lengthwise follow-up when ponderal increment is assessed; it is not suitable for cross-sectional assessments.47

The weight/height ratio corresponds to the relationship between real weight and ideal weight, which is equivalent to the 50th percentile of their age. This indicator does not distinguish between lean body mass and fat mass, which is a very important piece of information at this stage of life.47

The weight/height indicator is not expressed in percentile in the NCHS table. An adaptation has to be used to calculate the adequation of this indicator: first, the height presented by the teenager should be checked against the height/age chart to determine the corresponding age in the 50th percentile, considering this as the expected for the observed height (Table 3).48

\[
\text{Adapted weight/height} = \frac{\text{observed weight}}{\text{Weight in the 50th percentile for the age of the observed height}} \times 100
\]

<table>
<thead>
<tr>
<th>Height/age adequation %</th>
<th>Weight/height adequation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;95%</td>
<td>Overweight</td>
</tr>
<tr>
<td>≤95%</td>
<td>Overweight with height involvement</td>
</tr>
<tr>
<td>≥110%</td>
<td>Classic obesity</td>
</tr>
<tr>
<td>&lt;120%</td>
<td>Obesity with height involvement</td>
</tr>
<tr>
<td>≥120%</td>
<td>Obesity with height involvement</td>
</tr>
</tbody>
</table>

Table 3 - Nutrition status according to the World Health Organization classification
Even though percentiles are widely accepted and recommended in nutritional assessment studies as far as population is concerned, health professionals are much more acquainted with adequation rates as a diagnostic tool at individual level.

The height/age ratio is an extremely useful indicator in cross-sectional and longitudinal assessments of adolescents, used in severe malnutrition. This ratio is a historic indicator of adolescent growth pattern, using reference standards and is usually available.44

Body mass index (BMI) or Quetelet index is obtained by dividing weight (in kilograms) by squared height (in meters).49 The validity of BMI is based on the good correlation with body fat, especially internal fat, which, in its turn, is associated with risk factors for chronic diseases.30,51 However, fat mass is not distinguished from lean mass, thus making it difficult to differ between fat mass in overweight and muscle hypertrophy, as is the case of athletes. Association with other indicators such as skinfolds is very useful, allowing us to distinguish the composition of body mass presented by the BMI.46 This way, it is possible to calculate body fat mass index (BFMI) and body fat free mass index (BFFMI).

\[
BFMI = \frac{\text{fat mass (Kg)}}{\text{height}^2 \text{ (m)}}
\]

\[
BFFMI = \frac{\text{lean mass (Kg)}}{\text{height}^2 \text{ (m)}}
\]

Through these indices, it is possible to properly interpret percentage fat and total fat obtained through methods that assess body composition of individuals with different heights.52 The use of BMI in adolescents has been validated by several studies, presenting high specificity for the diagnosis of obesity, with a 95th percentile cutoff point.34,39,53 Its use is restricted by low sensitivity, that is, several false negatives when diagnosing adolescents at risk for obesity.54 Sichieri proposed a different cutoff point from that recommended by the World Health Organization for Brazilian population, based on data from the PNSN; however, this still depends on validation.55 By adopting 85th percentile cutoff point with the aim of detecting adolescents at risk, it is possible to increase sensitivity and then proceed to a second screening level.36,41 However, 85th percentile cutoff point may not be enough sensitive to diagnose overweight adolescents since it is based on criteria that are more statistical than epidemiological. In other words, the criterion for the cutoff points recommended by the World Health Organization is not associated with lower morbidity or mortality in adulthood, but associated with NCHS distribution extremes, which, for some authors, is an arbitrary criterion.44,55,40 The BMI is also limited once it does not reflect height deficiencies, which are very common among Brazilian low socioeconomic level adolescents.56

The lower BMI limit, which defines leanness, should be assessed together with sexual maturation stage. Low weight, especially in adolescents who have not been through the growth enhancement stage yet, may compromise growth, since nutritional requirements increase at this stage in order to compensate for the increase in body dimensions.3

Although the BMI does not provide information on body composition, it is an easily applicable assessment method as it uses anthropometric weight and height data, and as previously mentioned, can be easily obtained. Another advantage is that it presents good reproducibility.49,50,54

Skinfold measurement allows assessing body composition.57 Subcutaneous fat accounts for a great part of total body fat and varies according to age, gender, and fat content. Skinfolds are differently correlated with total body fat and percentage fat in terms of assessed location. Subscapular skinfold has a good correlation with total body fat, whereas triceps skinfold has a better correlation with total body fat content, especially in males, and is the most validated skinfold measurement, and is a good indicator of energy reserves, well-correlated with body fat and presenting references for all ages.35,47 Marshall et al., by means of validation studies on anthropometric indicators for children and adolescents between 7 and 14 years old, showed that the sum of the 4 commonly assessed skinfolds (triceps, biceps, subscapular and suprailiac) was the one that presented the best sensitivity for the diagnosis of obesity, for males and females, but with lower specificity.35

The method is greatly restricted by the necessity of highly-trained personnel, as errors are quite common when this requirement is not fully met, thus hindering reproducibility. Level of obesity is also a limiting factor for this method, as it is extremely difficult to measure skinfolds in obese patients.45,47

Mid-upper-arm circumference is an indicator that may be used alone or associated with triceps skinfold to assess body composition. The World Health Organization recommends its use when weight and height data are not available, as it is practical and performable during clinic examination.47,58

Methods used for assessment of body composition

Many so-called laboratorial methods, although some are now portable, have been designed for the assessment of body composition. However, these methods are inadequate for population studies and clinical practice; they are usually expensive and restricted to specialized research centers. A great advantage of this method is its use for validation of other commonly applied indicators.35,44

Hydrodensitometry is carried out by using underwater weighing and is based on the principle that the volume of a submerged body equals the volume of water it moves; thus,
Knowing the volume and mass, it is possible to calculate density. Calculations are made considering the differences in fat mass and lean mass density, and then an equation is formulated in order to convert total body density into percentage fat and fat-free mass. In adults, fat and fat-free mass density are assumed as 0.9 g/ml and 1.1 g/ml, respectively. However, in children and adolescents, the differences as to gender, ethnicity, and maturation stages, require specific knowledge about the density of these two assessed components, as lean mass increases their density from birth up to the age of 22. This method is normally used as reference standard for validation of other nutritional assessment tools.

**Mass spectrometry** is a technique by which total body potassium is calculated through its isotope. It is based on the fact that most part of body potassium is found in the fat-free mass nonosseous component. This is considered as a classical two-compartment method, dividing the body into fat mass and fat-free mass, requiring more sophisticated technology than hydrodensitometry. This technique is reliable, although it is clear that some facts may interfere with the assessment.

**Hydrometry** is a method that assesses body composition through body water content. In this method, an isotope (H2 or O18) is orally provided and, after some time, isotope concentration is determined in body fluids such as urine, blood or saliva; and the water content value is extrapolated according to the principle of dilution. To estimate lean mass, age-specific hydration factors are used. Fat mass is obtained through the difference.

**Near-infrared spectrometry** is based on the fact that body fat absorbs light from a specific wavelength within the near-infrared band of the electromagnetic spectrum. The device emits this wavelength, and through an internal optical sensor, it measures how much energy was absorbed by body fat. A built-in microcomputer interprets this absorption, and by combining it with weight and height data, calculates fat content. It is a fast, easy-to-use and safe method, applicable in the field and in clinics. However, in spite of its practical advantages, this method assumes that the composition of the irradiated part of the body is strongly related to the body as a whole, which, in some cases, does not occur. In agreement with these statements, validation studies have shown low correlation with other methods, with gross errors regarding body fat extremes, failing to add new information except those supplied by anthropometry such as skinfold measurements.

**Electrical bioimpedance (EB)** is a method based on the resistance to the passage of electric current through organic tissues, which have different water and electrolytic content. Lean mass, having a higher water and electrolyte content, is a better conductor of electricity than bone and fat mass. Consequently, the predictive equations are formulated by means of body water, providing total water and fat-free mass contents. This method employs electrodes placed at

body extremes (hands and feet), on a lying patient—horizontal bioimpedance. It is a frequently used method due to its low cost, easy operation, portability and safety, although it is not sensitive enough to detect changes in body composition that occur during nutritional interventions or physical training. To use this method in children and adolescents, gender and age-specific equations are necessary, since water and electrolyte content varies a lot in these groups.

One of the criticisms to EB is that it regards human body as a perfect cylindric conductor, which is not true; in addition, variation of body hydration levels can also interfere with results. However, several validation studies have been conducted using EB, presenting good correlations with reference methods.

Another recent method, which uses the same principle of EB, is vertical bioimpedance, also known as Tanita body-fat analyzer. It consists of a metal sole-plate that incorporates electrodes, on which subjects stand bare-footed, used for simultaneously measuring weight and impedance. Body fat is calculated through standard equations, using the data obtained, along with manually provided height and gender. When compared to EB, we observe that the accuracy between both methods is slightly different; however, as the Tanita body-fat analyzer is more practical to use, it is more suitable for field work.

**Ultrasonography** uses ultrasound waves with a frequency above 20kHz. This method is based on ultrasound reflection at the interfaces (echos) of several body tissues or on the Doppler effect produced by movements in internal structures. Although it is a safe method, it is not recommended for the assessment of body composition, especially subcutaneous fat, since its measurement offers great variability, which is mainly attributed to the direct compression of fats by the analyzer, thus leading to imprecise results.

In **Nuclear magnetic resonance (NMR)**, images are obtained through the interaction between an intense magnetic field with specific frequency (resonance frequency) and the magnetic field of the nuclei that form many of the atoms present in patients’ body organs and tissues. Even though this method produces clear and accurate images, it seemingly underestimates visceral fat if compared to CAT scan, and it is also expensive. It is worthy mentioning that NMR does not use any type of ionizing radiation for image composition.

In **CAT scan**, an X-ray beam (ionizing radiation) is conveyed through a section (cut) of patients’ bodies, allowing the view of internal structures with or without minimum interference by adjacent structures. The image of internal structures of each section is obtained through conjugated rotational movements of both ionizing radiation source (X-ray tube) and detector. Although it is considered a reference standard in comparison with other indirect methods for the assessment of body composition, its use is contraindicated due to the high content of ionizing radiation.
DEXA (dual-energy x-ray absorptiometry) has been widely used recently. It was initially designed for bone densitometry, and consists of X-ray emissions (ionizing radiation) with two different energy levels. These rays are attenuated when they pass through the body, but the extension and attenuation rate depend on the mass and type of tissue that is penetrated (bone tissue and fat-free mass). The accuracy of DEXA has been validated by other methods, allowing the assessment of tissue composition in specific parts of the body and detection of slight changes in fat and fat-free mass. This method has also been widely used for the validation of other indicators as it has comparability standards with hydrodensitometry and highly accurate measurements. An important advantage presented by DEXA, and which is usually a limitation to other methods, is that it does not depend on predictive equations with populational basis.

Conclusions

On defining methods for the assessment of nutritional status, we should select those that better detect the nutritional deficiencies we want to correct, also taking into consideration their costs, level of personal skill required for their proper application, necessary time for application, acceptability by the studied population and possible health risks.

Although the methods for the assessment of body composition that use ionizing radiation provide more accurate information if compared to others, it is important to emphasize that the justification of medical exposure is the major principle of the radiological protection system established by the Ministry of Health in regulation nº453 from the Sanitation Surveillance Secretariat. When using this principle, we should previously consider the efficacy and benefits of available alternative techniques that have the same objective, but which involve less or no exposure to ionizing radiations. This way, methods such as anthropometry - skinfold measurements - or those that do not use radiation - horizontal or vertical EB - should be considered on choosing a method for the assessment of body composition.

References


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