# Practical guide for assessing pediatric body composition

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## Resumen

Se presenta en este artículo una síntesis de tres métodos fáciles, económicos y confiables para evaluar la composición corporal en niños mayores de 8 años. La validez de estos métodos en la práctica clínica ha sido corroborada en diferentes investigaciones realizadas por el autor y sus colaboradores. Estos métodos pueden ser de utilidad en Colombia como una opción para realizar una evaluación rápida, de la composición corporal en grupos de niños y adolescentes.

**PALABRAS CLAVE:**
Masa libre de grasa, pliegues de grasa, análisis de impedancia bioeléctrica, índice de masa corporal (IMC), adiposidad.

## Summary

This article presents a synthesis of three easy, unexpensive and reliable methods for evaluating body composition in children over 8 years of age. The validity of this methods in clinical practice has been corroborated in several researches made by the author and his colaborators. This methods will be useful in Colombia as an option to make fast evaluations of body composition in groups of children and adolescents.

**KEYWORDS:**
Fat free mass, skinfolds, Bioelctric impedance Analysis, Body Mass Index (BMI), Adiposity.

*In this article we discuss some low cost, practical methods for estimating body composition in children and adolescents*

## INTRODUCTION

Quantifying the main body components is vital to the study of growth and the assessment of physical human characteristics, which are important both in the anthropological and medical fields (1). Body composition is influenced by endogenous and environmental factors, and it is a valid indicator of pathological changes especially to the diagnosis of human obesity and other nutritional disorders (i.e.: bulimia and anorexia) (2). Accurate measures of body composition are required as scaling factors to normalize physiologic variables (e.g., metabolic rate, physical activity, and physical fitness)(3). As described in the classic work published by the Heymsfield's group in 1992 (4) the composition of the human body can be divided into the following four models: an atomic model (i.e., oxygen, carbon, hydrogen, etc), a molecular model (i.e., water, lipid, protein, mineral and glycogen), a cellular model (i.e., cells, extracellular fluid, extracellular solid), or a tissue model (i.e., skeletal muscle, adipose tissue, visceral organs and residuals). In regard to pediatric obesity research, the most useful model is probably the molecular component. Fat and fat free mass are the terms used frequently that refer to the classic two-component body composition model in which body is divided into fat and non fat tissue mass (5).

Measurements of body composition are extremely challenging, because we do not have direct measurements except in vivo neutron activation analysis and chemical analysis of cadaver. We have various indirect methods to measure fat and fat free mass. All of them need assumptions, and age-specific considerations. We do remember that age and growth influence hydration and density of fat-free mass (6).

In this article we discuss some low cost, practical methods for estimating body composition in children and adolescents. We also offer guidance on practical, low-cost methods for making and refining these estimates. Specifically, we will focus on three specific methods of estimating body composition and fatness level: a. body mass index, b. skinfold measurements, and c. bioimpedance analysis.

### 1. BODY MASS INDEX (BMI)

Quetelet's Body Mass Index (BMI) is an expression of relative weight to height where weight (W) is measured in kilograms and height (H) is measured in meters (7):

BMI = W (in kg) ÷ H2 (in meters)

This index has the advantage of being inexpensive, safe, and easy to measure. It only requires a standard scale and an accurate way to measure height. BMI is commonly used to determine the health weight for height. There are some studies that find the correlate of the BMI with the body composition in groups of sedentary adults (8). Although other methods for determination of body composition may provide more accurate fat estimates, BMI is widely used to characterize childhood fatness in large epidemiological studies (9).

Recently we compared BMI estimates of body fat against dual energy X-ray absorptiometry (DXA), a state of the art measurement of body composition, in a large pediatric sample and found a significant association between the two methods (10, 11). Specifically, BMI was strongly associated with total body fat (R2=0.85 and 0.89 for boys and girls, respectively) measured by DXA. It is important to say that BMI needs a following of the subject and a complement with others methods to estimate body composition in individual studies, although we demonstrate that BMI will be easy, non-invasive and effective to determine body composition for the studies in groups of children and adolescents without any physical activity. (10)

Previous studies with a variety of body composition reference methods and differing subject populations largely support the validity of BMI as a reasonable surrogate of body fatness in children and adolescents (12- 15). Recently Cole and colleagues (16) proposed a definition using age-sex-specific centiles of the BMI pooled from several nationally representative data sets. In conclusion the paper has provided cut-off for BMI in childhood, which are linked to the widely accepted cut-off of BMI 18.5, 25 and 30 in adults (16). An important concern is whether or not BMI in children or adolescents as is in adults correlates with health measures such as serum insulin and blood pressure. Previous studies found a highly significant correlation between BMI, serum insulin levels, (17) systolic and diastolic blood pressures in children and adolescents (18)

A reasonable conclusion based on these investigations is that BMI reliably reflects fatness on a group level and, in turn, BMI is associated with various adverse biochemical and physiological effects of excessive adiposity.

## 2. SKINFOLD MEASUREMENTS

A long-standing method for determining body fat is skinfold measurements. This method is widely applied and can be used alone in evaluating nutritional status in pediatric population or incorporated into prediction formulas for component estimation (19). This technique uses special calipers to "pinch" and ascertain the thickness of skinfolds at specified body sites (20). A high-quality skinfold caliper and a flexible measuring tape are required for the measurement. We summarized in table 1 some practical issues for a correct measurement. Validity of this approach has been demonstrated in children. Age- and race-specific equations for estimating body fat were developed by Slaughter et al. (21) (using multicomponent model reference measures). These equations use the sum of two skinfolds (triceps + subscapular for equation 1 and triceps + calf skinfolds for equation 2) to predict percent body fatness and are summarized in table 2. There are equations for each maturation level in agreement with Tanner (22), thus:

Pre puberty: phase 1 and 2

Puberty: phase 3

Post puberty: phase 4 and 5.

## TABLE 1
**Practical issues for taking skinfold measurements.**

- To take all measurements on the right side of the body.
- To take the skin between the thumb and the index finger of the left hand.
- To lift the fold by placing the thumb and index finger approximately three inches apart on a line that is perpendicular to the long axis of the skinfold.
- To keep the fold elevated while the measurement is taken.
- To place the jaws of the caliper perpendicular to the fold and release the jaw pressures slowly.
- To take a minimum of two measurements at each site and averaged.
- To read the results of the caliper to the nearest measurement.
- To have a well-trained skilled assessor.

## TABLE 2
**Equations of Slaughter et al (20) in predict percent body fat.**

| **A. Triceps (Tr) and Calf (Ca) Skinfolds** | |
|---|---|
| Gender | Percent Body Fat |
| Boys | 0.735 (Tr + Ca) + 1.0 |
| Girls | 0.610 (Tr + Ca) + 5.1 |
| **B. Triceps (Tr) and Subscapular (Su)** | |
| Gender and Race | Percent Body Fat |
| White boys | |
| Prepubescent | 1.21 (Tr + Su) - 0.008 (Tr + Su)2 - 1.7 |
| Pubescence | 1.21 (Tr + Su) - 0.008 (Tr + Su)2 - 3.4 |
| Pospubescent | 1.21 (Tr + Su) - 0.008 (Tr + Su)2 - 5.5 |
| Black boys | |

| | |
|---|---|
| Prepubescent | 1.21 (Tr + Su) - 0.008 (Tr + Su)2 - 3.2 |
| Pubescence | 1.21 (Tr + Su) - 0.008 (Tr + Su)2 - 5.2 |
| Pospubescent | 1.21 (Tr + Su) - 0.008 (Tr + Su)2 - 6.8 |
| All girls | 1.33 (Tr + Su) - 0.013 (Tr + Su) - 2.5 |

**C. If sum of triceps and subscapular skinfolds are greater than 35 mm, apply the following equations:**

| Gender | Percent body fat |
|---|---|
| All boys | 0.783 (Tr + Su) + 1.6 |
| All girls | 0.546 (Tr + Su) + 9.7 |

The prediction errors for these equations ranged from 3.6% to 3.9% body fat. These equations may be used to assess body composition of boys and girls 8 to 17 years of age (21).

Rolland-Cacherà (23) noted that anthropometric measures taken at different sites correlate differently with total-body fat and percent body fat. Specifically, triceps have a better correlation with %body fat while subscapular skinfolds correlate better with total-body fat. These measurements are useful indicators because of their relationships with risk factors.

3. BIOIMPEDANCE ANALYSIS (BIA)

Using bioimpedance analysis methods (BIA) the electrical impedance of the body is measured by introducing a small alternating electrical current into the body and measuring the potential difference that results. The impedance magnitude (Z) is the ratio of the magnitude of the potential difference to the magnitude of the current. Alternating electrical current flows through the body by several different physical mechanisms (24).

Tissues rich in water and electrolytes offer considerably less resistance to passage of an electrical current than do lipid-rich adipose tissue. Conceptually, a human devoid of adipose tissue would have a minimum impedance what would increase to a maximum when all lean tissue was replaced by fat-filled adipose tissue (25). A limitation of BIA is that it provides an estimate of total water. For this reason, the hydration of the fat-free mass must be known. It is constant in adults (73.2%) but varies in children. At the age of 5 years the hydration is 77.0 and 78.0 for boys and girls respectively. At the age of 10 years the hydration is 76.2 for boys and 77 for girls (26). Age specific equations have been recommended, because age related differences in electrolyte concentration in the extra cellular space relative to the intracellular space may alter the relationship between bioelectrical resistance and total body water (27).

Until recently body composition by BIA has employed a single frequency of 50 kHz, most commonly measured between the wrist and an ipsilateral ankle. In accordance with the axioms of impedance plethysmography, the total body resistance measurement (R) is combined with stature as the length of the conductor (S) to compute stature squared divided by resistance (S2/R) as an index of the total conductive volume of the body (28). The ability of this impedance index to describe the volume of fat-free mass (FFM) is due to grater electrolyte content and measured conductivity of FFM compared with adipose tissue or bone (25, 28). Fat can then be calculated as the difference between body weight and fat-free body mass (24, 25, 29).

An important issue is that subject measurement conditions must be rigorously standardized in order to obtain accurate body composition estimates. Room and subject temperature, position of the patient, correct electrode placement, the use of appropriate equations age specific and a multitude of controllable factors influence measured impedance and must be standardized to the extent possible during BIA measurements. We consider this the first step in obtaining reliable BIA body composition measurement (28). For a more in-depth review of the physical concept of BIA, the reader is referred to the work of Yanovski, Heymsfield, and Lukaski (28). We summarize in table 3 the BIA measurement procedure.

## TABLE 3
**BIA measurement procedure.**

- Take on the right side of the body with the child supine on a non-conductive surface.
- Clean the skin at the electrode sites.
- Place the sensor electrodes on the dorsal side of the wrist and ankle.
- Place the source electrodes at the base of the second third metacarpal/metatarsal-phalange joint of the hand and foot.
- The arms and the legs of the child will be abducted approximately 45° to each other.

We may conclude that BIA can be used to accurately assess body composition in prepubertal children, pubertal children, and adolescents using the appropriate equation (21). On table 4 we summarize some prediction equations for children.

## TABLE 4
**Prediction equation for children using BIA.**

| Method | Ethnicity/gender | Equation | Reference |
|---|---|---|---|
| BIA | White/ Boys and girls (6 - 10 yrs) | TBW=0.593(Ht2/R) + 0.065(BW) +0.04 | (28) |
| | White/ Boys and girls (10 - 19 yrs) | FFM (kg)=0.61(Ht2/R) + 0.25(BW)+1.31 | (29) |
| | White/ Boys and girls (8 - 15 yrs) | FFM(kg)=0.62(Ht2/R)+0.21(BW) + 0.10(Xc)+4.2 | (19) |

TBW = total body water; Ht = height (cm); BW = weight (kg); FFM = fat free mass; Xc = reactance (*)

# Conclusion

Body composition measures can be used to monitor and classify the level of fatness. Research shows that fatter children have a strong tendency to be obese as adults and a relatively greater health risk for cardiovascular disease (32).

We may conclude:

1. Body weight and body height and subsequently BMI are essential parameters to follow growth and development in children. It is suggested by some that these parameters be measured regularly from birth to better detect deviations from normal development (i.e.; growth retardation or overweight / obesity) (16).
2. Skinfolds measurement is a good measure of subcutaneous adipose tissue and can be used to estimate total body fatness in children and adolescents. In order to reduce the measurement error is important to follow standardized measurements procedure. Off course we need to take into account that it is fundamental to use the appropriate equation for the population that you are measured (32).
3. The value of BIA in the estimation of body adiposity both on a clinical basis in the individual and epidemiologically in large groups to define the presence or prevalence of obesity, respectively, is of great interest. BIA appears to

be a more accurate in measuring FFM and percentage of body fat than body weight, height, or body mass index (25). BIA may provide a more accurate measure than do skinfold measurements and may be more easily standardized (32).

### For the clinicians pediatricians

Overweight and obesity development involves complex interaction among diet, metabolic, physical activity and genetic related factors. It is important to know nutritional factors, energy intake, composition of the diet, nutrition and hormonal status, food preference and behavior, and the influence of non-nutritional factors. Take all together with an accurate and precise body composition assessment we have the possibility to control growth process and to reduce the risk factors of various disease.

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