ISSN: 2640-4133

Review Article

Advances in Bioengineering & Biomedical Science Research

Methods to Estimate Body Composition, Comparing Electrical Bioimpedance and Other Methods

Patino LD[1]*, Champagne V[2] and Yudchak CG[3]

[1]*Department of Internal Medicine, School of Medicine, University of Buenos Aires, Argentina*

[2]*Department of University Extension and Welfare, University of Buenos Aires, Argentina*

[3]*Department of Emergency and Domestic Violence, University of Buenos Aires, Argentina*

***Corresponding author**

Patino LD, Department of Internal Medicine, School of Medicine, University of Buenos Aires, Argentina, E-mail: drdpat@gmail.com

Submitted: 24 Jan 2019; **Accepted:** 02 Feb 2019; **Published:** 19 Feb 2019

Abstract

Measurement of body composition is an issue of growing interest that can be used to science research or clinical purposes. For professionals at the health sciences field, it is important to know characteristics of different methods of evaluation and analysis of body composition in order to decide what method should be used in each case, to carry out a better evaluation of the state of health and the risk of a person to becoming ill (by deficit or excess). Then, using these data, it could be performed the corresponding therapeutic strategy.

Specifically for patients with eating disorders, a complete evaluation of it is useful, mainly due to body changes, increases or decreases in fat mass and lean mass (for example in anorexia nervosa, bulimia nervosa or binge eating disorder). A similar strategy could be assumed to patients with overweight or obesity.

Background

Nowadays, methods to analyse body composition are divided into three groups: direct, indirect and doubly indirect. In this work, we are going to refer to doubly indirect.

Methods

Anthropometry and bioelectrical impedance. The electric bioimpedance (EB) is a non-invasive method and it is easy to apply in all types of populations. Knowing its operation, its physical bases, its use and the strict application of the conditions of measurement will ensure the obtained results reliability to get a better comprehension of data. The doubly indirect methods such as anthropometry and bioelectrical impedance stand out from others, because of their simplicity, safety, facility of interpretation and low cultural restrictions. In addition, they present a practical and accessible application, which allows their use in epidemiological studies and research at a population level.

Anthropometry

Among all techniques used in anthropometry, the body mass index (BMI) is the most used, providing information about the subjects' nutritional status.

BMI: weight (kg) or (pounds) / [height (m) or (feet)]. This is the unit of measurement most used in the consultation to estimate the nutritional status of the patient.

However, BMI does not discriminate between different compartments in the organism. The changes in the BMI are directly proportional to the change in weight. The BMI assumes a distribution into muscle mass and fat mass that is not true. BMI generally overestimates adipose tissue in those who have higher body mass (for example athletes) and underestimates excess fat in those who have lower body mass. A study in June 2008 by Romero-Corral examined 13,601 subjects from the United States and found that obesity (BMI> 30) was present in 21% of men and 31% of women. However, using the percentage of body fat it was found obesity in 50% of men and 62% of women, despite the sub-recount that estimated the BMI. In fact, BMI values were associated with large percentages of body fat.

A study published by the Journal of the American Medical Association in 2005 showed that overweight people have a similar risk of death than people with normal weight as defined by the BMI, whereas those who have a "below" normal weight "have greater chances of dying".

Therefore, BMI is considered as an estimative index to evaluate the nutritional status. To make a correct diagnosis, you need diagnostics can be supported by other methods.

Table 1: The international classification of adult underweight, overweight and obesity according to BMI

Classification	BMI (kq/m²)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	18.50 - 24.99	18.50 - 22.99
		23.00-24.99
Overweight	≥25.00	≥25.00
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50-29.99
Obese	≥30.00	≥30.00
Obese class I	30.00 - 34.99	30.00-32.49
		32.50-34.99
Obese class II	35.00 - 39.99	35.00-37.49
		37.50-39.99
Obese class III	≥40.00	≥40.00

Source: Adapted from WHO 1995, 2000, 2004 and 2006.

The relationship between waist circumference and hip is also another anthropometric technique widely used and it is recommended by the World Health Organization as a good predictor of central obesity in population studies since it allows the evaluation of metabolic risk. The measurement is made with a measuring tape, but in this case, the healthcare professional must be trained to reduce the margin of possible error.

Table 2: International classification of waist circumference values (centimeters)

Evaluation	Parameters (cm)	
	Woman	Mens
Normal	Lower tan 80	Lower tan 94
high risk	80-87, 9	94-101, 9
Very high risk	equal or greater than 88	equal or greater than 102

Source: Adapted from WHO, 2008.

These two anthropometric measurements are especially important because high values in the BMI or waist-hip ratio are associated with a higher incidence of mortality, diabetes, and cardiovascular diseases. Another anthropometric technique, widely used is the measurement of different skin folds, is based on the fact that most of the body fat is in the subcutaneous tissue. Taking into account that in different body parts, there are some regions with more amount of fat and other regions with less of it, the measurements of skin folds should be made in different areas of the body. This measuring technique is used to estimate the body density operating some mathematical equations, developed in different population groups with diverse characteristics. The calculated values of body density allow estimating the fat mass and lean body mass. This method has the following disadvantages, it has a large margin of error (between 3% and 11%), it presents variability when measurements are made by different people, with different training level or by different instruments, and its implementation is difficult in obese people or with large amounts of fat, dehydration or fluid retention.

Bioelectrical Impedance

The bioelectrical impedance is used to calculate the total body water, fat mass, and fat free mass. This method measures the impedance by a small electrical current applied through the body. The impedance varies according to the tissue that is being evaluated. For instance, fat-free mass presents a good electrical conductivity due to its high concentration of water and electrolytes, while the fat mass is not a good electrical conductor. That allows us to say that impedance is directly proportional to the amount of body fat. This method has disadvantages such as limitations of application in patients with fluid retention, peripheral edema, hydrostatic problems or taking diuretic medication. Using in athletes measurement is not an adequate method since it has an error of 3%, which is too big. In the bioimpedance method, the percentage of Visceral Fat mass is also determined, which accumulates in the abdomen and in the vital organs that surround it. This type of fat increases the risk of death when its percentage is high, visceral fat is related to high levels of fat in the bloodstream. Also, it is related to noncommunicable chronic diseases.

Table 3: Comparison between different methods of nutritional evaluation

METHODS OF BODY COMPOSITION MEASUREMENT	Accessibility	Specificity	Precision	Reproducibility	Adventages	Disadvantages
EB	High	Low	Half	CV 4-9,8%	Cheap Laptop insurance Practical Quick Determine fat component and fat-free mass and visceral fat	For specific population, poor precision in individuals and groups
ANTHROPOMETRY (BMI, waist circumference, folds)	Very high	Low	Low	Very variable	Cheap Noninvasive	Low reproducibility, sensitivity and specificity The margin of error is high

Source: Adapted from Costa Moreira, et al. 2015.
cv. coefficient of variation

Discussion

Final Considerations. It is possible to observe that there are several methods to measure body composition and each one has advantages and disadvantages. The healthcare professional who will perform a measurement of the body composition should choose among these methods, considering the following variables:

- According to their objective
- Always consider benefits and costs to apply each method
- The level of his/her own training as an evaluator
- Time available to proceed
- The reliability of the method
- Possible risks of application

Proceeding in this way helps us to minimize disadvantages and to potentiate advantages of the chosen method.

After reviewing data, we can conclude that using electrical impedance (BIA) for analysis of body composition, presented as a non-invasive technique of great precision that in a short period of time allows to obtain reliable data evaluating the state of hydration and nutrition, discriminating the balance between fat mass and lean mass, we could improve a medical-nutritional intervention in the associated pathologies treatment as overweight, obesity and eating disorders.

We believe that body composition, and not just total body mass, should be assessed when studying the effects of patients' weight on health issues. The determination of these values in time can play an important role in the decision making for the professional and provide a healthy state and better quality of life for the patient. Strategies for weight loss should aim not only to reduce body weight, but also to reduce fat and increase muscle as well as the accompaniment of eating habits to achieve these objectives.

Otherwise, without specific control, the patient could lose weight at the expense of muscle mass and bone density. That would be a risk to health. Still losing weight, the basal metabolism is making the body more prone to store fat. In this way, both body components (fat mass and lean mass) can be monitored to increase skeletal muscle to prevent further weight gain [1-33].

References

1. Moran JM, Lavado-Garcia JM, Pedrera-Zamorano JD (2011) Methods for nurses to measure body composition. Rev Lat Am Enfermagem 19: 1033-1038.
2. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, et al. (2011) American College of Sports Medicine. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 43: 1334-1359.
3. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, et al. (2009) American College of Sports Medicine. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc 41: 459-471.
4. Porbén SS, Borrás AL (2003) Composición corporal. Acta Medica 11: 26-37.
5. Wang ZM, Pierson RN Jr, Heymsfield SB (1992) The five-level model: a new approach to organizing body-composition research. Am J Clin Nutr 56: 19-28.
6. Heymsfield SB, Pietrobelli A, Wang Z, Saris WH (2005) The end of body composition methodology research? Curr Opin Clin Nutr Metab Care 8: 591-594.
7. Shah AH, Bilal R (2009) Body Composition, its Significance and Models for Assessment. Pakistan Journal of Nutrition 8: 198-202.
8. Sant'anna MSL, Priore SE, Franceschini SCC (2009) Métodos de avaliação da composição corporal em crianças. Rev Paul Pediatr 27: 315-321.
9. Lustgarten MS, Fielding RA (2011) Assessment of analytical methods used to measure changes in body composition in the elderly and recommendations for their use in phase II clinical trials. J Nutr Health Aging 15: 368-375.
10. Ayvaz G, Çimen AR (2011) Methods for Body Composition Analysis in Adults. The Open Obesity Journal 3: 62-69.
11. Rantalainen T, Weeks BK, Nogueira RC, Beck BR (2015) Effects of bone-specific physical activity, gender and maturity on tibial cross-sectional bone material distribution; a cross-sectional pQCT comparison of children and young adults aged 5-29 years. Bone 72: 101-108.
12. Friedenreich CM, MacLaughlin S, Neilson HK, Stanczyk FZ, Yasui Y, et al. (2014) Study design and methods for the Breast Cancer and Exercise Trial in Alberta (BETA). BMC Cancer 14: 919.
13. Mueller SM, Knechtle B, Knechtle P, Toigo M (2014) Physiological alterations after a marathon in the first 90-year-old male finisher: case study. Springer plus 3: 608.
14. Thibault R, Genton L, Pichard C (2012) Body composition: why, when and for who? Clin Nutr 31: 435-447.
15. Lukaski H (1997) Sarcopenia: assessment of muscle mass. J Nutr 127: 994S-997S.
16. Honda A, Matsumoto M, Kato T, Umemura Y (2015) Exercise characteristics influence femoral cross-sectional geometry: a magnetic resonance imaging study in elite female athletes. Osteoporos Int 26: 1093-1098.
17. Osawa Y, Azuma K, Tabata S, Katsukawa F, Ishida H, et al. (2014) Effects of 16-week high-intensity interval training using upper and lower body ergometers on aerobic fitness and morphological changes in healthy men: a preliminary study. Open Access J Sports Med 5: 257-265.
18. Souza-Teixeira F, Costilla S, Ayán C, García-López D, González-Gallego J, et al. (2009) Effects of resistance training in multiple sclerosis. Int J Sports Med 30: 245-250.
19. Kaul S, Rothney MP, Peters DM, Wacker WK, Davis CE, et al. (2012) Dual-energy Xray absorptiometry for quantification of visceral fat. Obesity (Silver Spring) 20: 1313-1318.
20. Shuster A, Patlas M, Pinthus JH, Mourtzakis M (2012) The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis. Br J Radiol 85: 1-10.
21. Zhao X, Wang Z, Zhang J, Hua J, He W, et al. (2013) Estimation of total body skeletal muscle mass in Chinese adults: prediction model by dual-energy X-ray absorptiometry. PLoS One 8: e53561.
22. Pietrobelli A, Formica C, Wang Z, Heymsfield SB (1996) Dual-energy X-ray absorptiometry body composition model: review of physical concepts. Am J Physiol 271: E941-E951.
23. Plank LD (2005) Dual-energy X-ray absorptiometry and body composition. Curr Opin Clin Nutr Metab Care 8: 305-309.
24. Wang Z, Heymsfield SB, Chen Z, Zhu S, Pierson RN (2010)

Estimation of percentage body fat by dual-energy x-ray absorptiometry: evaluation by in vivo human elemental composition. Phys Med Biol 55: 2619-2635.

25. Beraldo RA, Vassimon HS, Navarro AM, Foss-Freitas MC (2015) Development of predictive equations for total and segmental body fat in HIV-seropositive patients. Nutrition 31: 127-131.
26. Kim SG, Ko KD, Hwang IC, Suh HS, Kay S, et al. (2015) Relationship between indices of obesity obtained by anthropometry and dual-energy X-ray absorptiometry: The Fourth and Fifth Korea National Health and Nutrition Examination Survey (KNHANES IV and V, 2008-2011). Obes Res Clin Pract 9: 487-498.
27. Lima TP, Nicoletti CF, Marchini JS, Junior WS, Nonino CB (2014) Effect of Weight Loss on Bone Mineral Density Determined by Ultrasound of Phalanges in Obese Women After Rouxen-y Gastric Bypass: Conflicting Results With Dual-Energy X-ray Absorptiometry. J Clin Densitom 17: 473-478.
28. de Knegt VE, Carlsen EM, Bech Jensen JE, Lade Rasmussen AM, Pryds O (2015) DXA Performance in a Pediatric Population: Precision of Body Composition Measurements in Healthy Term-Born Infants Using Dual-Energy X-ray Absorptiometry. J Clin Densitom 18: 117-123.
29. Rodrigues de Faria E, Rocha de Faria F, Siqueira Santos Gonçalves V, Castro Franceschini SD, Gouveia Peluzio MD, et al. (2014) Prediction of body fat in adolescents: comparison of two electric bio impedance devices with dual-energy x-ray absorptiometry. Nutr Hosp 30: 1270-1278.
30. Chen Z, Wang Z, Lohman T, Heymsfield SB, Outwater E, et al. (2007) Dual-energy Xray absorptiometry is a valid tool for assessing skeletal muscle mass in older women. J Nutr 137: 2775-2780.
31. Glickman SG, Marn CS, Supiano MA, Dengel DR (2004) Validity and reliability of dual-energy Xray absorptiometry for the assessment of abdominal adiposity. J Appl Physiol 97: 509-514.
32. Lidyce Quesada Leyva, Dra Cira Cecilia León Ramentol, José Betancourt Bethencourt, Elizabet Nicolau Pestana (2016) Centro de Inmunología y Productos Biológicos (CENIPBI). Elementos teóricos y prácticos sobre la bioimpedancia eléctrica en salud. versión On-line AMC 20: 5
33. Armando Sánchez Jaeger y María Adela Barón (2009) Uso de la bioimpedancia eléctrica para la estimación de la composición corporal en niños y adolescents. An Venez Nutr 22: 2.
34. Data Base on Body Mass Index (2006). http://www.assessmentpsychology.com/icbmi.htm.
35. WHO (World Health Organization), Waist Circumference and Waist-Hip Ratio Report of a WHO Expert Consultation, Geneva, 8-11 December 2008.
36. Osvaldo Costa Moreira, Diego A Alonso-Aubin, Cláudia E Patrocinio de Oliveira, Ramón Candia-Luján, José A de Paz (2015) Métodos de evaluación de la composición corporal: una revisión actualizada de descripción, aplicación, ventajas y desventajas. Arch Med Deporte 32: 387-394.