Bioelectrical impedance analysis (BIA) for sarcopenic obesity (SO) diagnosis in young female subjects

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Abstract. Sarcopenia is defined as a loss of muscle mass depending of ageing and affecting physical function (definition A). A new definition considers excluding mass reduction criterion (definition B). Obesity is pandemic and occurs at all ages. Sarcopenic obesity (SO) implies both processes. The purpose of this study was to compare the results obtained after applying these two definitions to 66 overweight or obese college women aged 22 ± 2.8 years. Percentage body fat (%BF) and skeletal mass index (SMI) were estimated by BIA, muscle function by handgrip strength test (HGS) and physical performance by Harvard step test (HST). There were 9.1% overweight and 90.9% obese subjects. Twenty nine subjects (43.9%) had decreased HGS and 22 (33.3%) had impaired physical performance. One obese subject (1.5%) met the criteria for sarcopenic obesity by definition A and 9 (13.6%) by definition B. Although a linear regression ($\alpha<0.05$) showed a very weak association between these variables ($r^2$ = 0.094, 0.037 and 0.275 respectively) it was observed a tendency for HGS, HST and SMI deterioration when %BF increases. However, other confounding factors must be investigated. Probably as the population gets more obese, the problematic of SO will be found earlier in life.

1. Introduction
Traditionally, sarcopenia has been defined as a set of signs and symptoms characterized by a progressive loss of all skeletal muscle groups associated to aging that can lead to physical disability and death (definition A) [1]. To make the diagnosis is required to have a reduced skeletal muscle plus low muscle strength or weak physical performance [2]. Nowadays, there is a proposal for changing this definition as there is growing evidence that muscle mass is not entirely related to muscle strength and that this variable is a better marker of functional limitation than muscle mass reduction. Thus, sarcopenia should be diagnosed by functional and physical limitation only (definition B) [3].

Obesity is diagnosed with a BMI greater than 30 kg/m$^2$ [3] or, more precisely, with a fat mass percentage greater than 37% in women aged 18 to 79 [4]. Obesity is pandemic [3], occurs at all ages and can affect muscle mass function [5, 6]. The global prevalence of overweight is 1 in 4 adults and it will be about 1 in 2 by 2015 [8]. Obesity generates muscle dysfunction due both, fat infiltration in muscle cells [9] and reduction of muscle protein synthesis [5, 10]. Sarcopenic obesity implies both processes: sarcopenia and obesity [7].

The use of Bioelectrical impedance analysis (BIA) to assess skeletal muscle mass, is relatively new but its use is increasing due to the results obtained by this method are comparable to those yielded by dual energy x-ray absorptiometry (DEXA) [11]. BIA results allow to estimate fat free mass (FFM)
and from it calculate the skeletal muscle mass index (SMI). The hand dynamometry has been used to
evaluate muscle strength of individuals. It has correlated well with malnutrition by both, excess or
deficit of energy. The method, easy of access and operation is very useful in clinical and population
studies [12]. The estimation of physical performance by the Harvard step test (HST) is appropriate to
examine the cardio respiratory reserve [13], one important conditional skill. The test is useful in
population studies and easily applied in the laboratory. We hypothesized that, given the high
percentage of overweight and obesity in the world, sarcopenic obesity is could start at earlier stages of
life. If this is true, preventive measures could be taken to retard or prevent muscle wasting in later.
Thus, this study aimed to compare the results obtained after applying these 2 definitions for sarcopenia
in a group of young college women having different levels of adiposity.

2. Materials and methods

2.1. Subjects
The methods, classified as minimum risk, were approved by the Bioethics Committee of the
University of Caldas. The purpose and procedures of the study were explained to a sample of 66
young college females. Inclusion criteria were: being female, aged 18 to 24 years and with no
comorbidities. Exclusion criteria were: being a smoker, have metal implants or pacemakers, be
pregnant or be using diuretics. Subjects who had undergone surgery for weight reduction or silicone
breasts implants were also excluded.

2.2. Data acquisition
Measurements were performed early in the morning. Relative humidity and environment temperature
were controlled with an electric heater (BFH416 by Bionaire™) and a dehumidifier (BMD100 by
Bionaire™). Relative humidity and environmental temperature were measured with a thermo-
ygrometer (13307 by DeltaTrak®, ±0.1 ºC). Volunteers were asked to comply with standardized
requirements before the test and all volunteers were evaluated out of menses.

2.3. Anthropometric measurements
Height (Heightronic-235 by Seca®, ±0.01 cm) and weight (W) (PP2000 by Icob-Detecto®, ±0.1 kg)
were measured twice. A third measurement was taken if there was a difference greater than 0.5 cm or
0.1 kg respectively [14].

2.4. BIA measurements
Multi frequency Bioelectrical impedance was measured on the dominant side of body for three times
on a nonconductive surface (Hydra 4200 by Xitron Technologies©). FFM was obtained with internal
equation of the bioimpedance analyzer and %BF-BIA was calculated with %BF-BIA=((W-
FFM)/W)*100%. Estimation of skeletal muscle mass was made by using the data at 50 kHz with the
equation developed by Jansen et al, 2000 [15] then; the skeletal muscle index (SMI) was calculated
[2]. The classification by %BF was made using cutoffs by Gallagher et al, [4].

2.5. Handgrip strength
The handgrip (HG) was measured 3 times using a hydraulic dynamometer Baseline® (± 1 kg)
(Fabrication Enterprises Inc. USA) and following the guidelines of the American Association of Hand
Therapists [16].

2.6. Harvard step test
HST was performed by using a metronome Yamaha YM-2000 © to keep pace and three Casio HS3 ©
stopwatches to measure time [13]. The bench height was 35 cm for women. Results were expressed by
an index.
2.7. *Statistical methods*

Characteristics of the subjects and laboratory conditions were expressed as mean and standard deviation. Subjects with decreased SMI, HGS and HST according %BF were expressed as percentage. A linear regression ($\alpha=0.05$) was used to evaluate the association between body fat and the 3 parameters.

3. *Results*

Environmental conditions were kept stable: temperature was 19.5 ºC (±0.5), relative humidity was 72.4 % (±1.1). Table 1. shows subject’s characteristics. SMI, HGS, HST and %BF reference values were extracted from previous studies [2, 4, 13, 19]. Table 2 shows the number and percentage of subjects with values of SMI, HGS and HST out of reference values, according to their %BF.

One obese subject (1.5%) met the criteria for sarcopenic obesity by definition A and 9 (13.6%) by definition B. Although a linear regression ($\alpha<0.05$) showed a very weak association between these variables ($r^2=0.094$, 0.037 and 0.275 respectively) it was observed a tendency for HGS, HST and SMI deterioration when %BF increases (Figure 1).

| Table 1. Subject characteristics | Table 2. Subjects with decreased SMI (Skeletal muscle index), HGS (Hand grip strength) and HST (Harvard step test) according %BF-BIA (% Body fat by bioelectrical impedance analysis) |
|---------------------------------|---------------------------------------------------------------------------------|
| Variables                      | Mean  SD                           | n by %BF-BIA level (%) | SMI | HGS | HST |
| Age (years)                    | 22.0 2.8                           | Thin 0 (0%)             | 0   | 0   | 0   |
| Height (cm)                    | 156.7 5.3                          | Normal 0 (0%)           | 0   | 0   | 0   |
| Weight (kg)                    | 55.0 8.3                           | Overweight 6 (9.1%)     | 0   | 1   | 0   |
| BMI (kg/m²)                    | 22.4 2.9                           | Obese 60 (90.9%)        | 1   | 28  | 22  |
| %BF-BIA                        | 32.6 4.7                           | Total group 66 (100%)   | 1   | 29  | 22  |
| %HGS (%)                       | 88.9 15.3                          | % of subject respect n=66 | 1.5%| 43.9%| 33.3% |
| SMI (kg/m²)                    | 7.9 0.6                            |                        |     |     |     |

Figure 1. Regression of (a) % Hand grip strength (%HGS) ($r^2=0.037$), (b) Harvard step test (HST) ($r^2=0.275$) and (c) Skeletal muscle index (SMI) ($r^2=0.094$); by % Body fat by bioelectrical impedance analysis (%BF-BIA)

4. *Discussion and conclusion*

Some authors define sarcopenic obesity as low muscle mass associated to high fat mass [7]. Muscle mass has been evaluated by different methods but cut off points to define these parameters are not unanimous [7]. On the other hand, although historically, sarcopenia has been related to a decline in
muscle strength and functionality in older people, the word sarcopenia comes from the Greek meaning "poverty of flesh" and it does not imply old age. In addition, several researchers have shown that quantity of muscle mass is not necessarily associated to loss of muscle strength and that more importantly is to define if a subject has less functionality and performance. Thus, detecting changes in muscle composition and quality is the primary concern for nutritionists and geriatricians and a predominant goal in medical care [3]. Thereby, definition of sarcopenic obesity may be controversial [7]. We hypothesized that as obesity produces low-grade inflammation, and hormonal changes affecting the muscle function and metabolism, obese young people could have similar changes and meet the criteria for the diagnose of sarcopenic obesity.

We chose two definitions to evaluate a group of young female college whose body fat percentage was between 27.9 and 37.3. By using the traditional definition of sarcopenia in this group of apparently healthy female college, one subject would be classified as having SO by definition A. By applying the definition B proposed by Stenholm et al [3], 9 young people obtained the same diagnosis. The low association between SMI, HGS, HST have been reported by others and evidence that muscle mass quantity is not entirely related to muscle strength is now clear [3].

It may be that subjects in this study were less physically fit or less active but these are conditions strongly related to obesity. Nevertheless, factors as nutritional conditions, physical activity, occupation, and body size associated to SO must be investigated as suggested by Parr et al, 2013 [5,10, 17]. It was found a total prevalence of 15.2% of SO subjects. Different definitions of SO may be produce polemical results. It is probably that as the population gets more obese, the problematic of SO will be found earlier in life and more research is desirable. This study is a contribution to a topic that is just beginning to be explored.

**References**

[1] Baumgartner RN, Koehler KM, Gallagher D, Romero L, Heymsfield SB, Ross RR, Garry PJ, And Lindeman RD 1998 Am J Epidemiol. 147 755-63
[2] Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E and Zamboni M 2010 Age Ageing, 39 (4) 412-23
[3] Stenholm S, Harris TB, Rantanen T, Visser M, Kritchevsky SB, and Ferrucci L 2008 Curr Opin Clin Nutr Metab Care. 11 693-700
[4] Gallagher D, Heymsfield SB, Heo M, Jebb SA, Mangatroyd PR and Sakamoto Y 2000 Am J Clin Nutr. 72 694-701
[5] Parr EB, Coffey VG, Hawley JA 2013 Maturitas. 74 109-13
[6] Ford ES and Mokdad AH, 2008. J Clin Endocrinol Metab. 93 S1-8.
[7] Prado CM, Wells JC, Smith SR, Stephan BC and Siervo M 2012 Clin Nutr. 31 583-601
[8] WHO, 2011. Global status report on non-communicable diseases 2010 Annex 4
[9] Hilton TN, Tuttle LJ, Bohnert KL, Mueller MJ and Sinacore DR 2008 Phys Ther. 88 1336-44
[10] Evans WJ, 2010 Am J Clin Nutr. 91 1123S-27S.
[11] Chien MY, Huang TY and Wu YT 2008 J Am Geriatr Soc. 56 1710-5
[12] Hulens M, Vansant G, Lysens R, Claessens AL, Muls E and Brumagne S 2001 Int J Obes Relat Metab Disord. 25 676-81.
[13] Johnson TJ, Brouha L and Gallagher JR 1943 Yale J Biol Med. 15 781-5
[14] Lohman TG, Roche AF and Martorell R 1988 Anthropometric standardization reference manual
[15] Janssen I, Heymsfield SB, Baumgartner RN and Ross R 2000 J Appl Physiol. 89 465-71
[16] Innes E 1999 Aust Occup Ther J. 46 (3) 120-140
[17] Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E and Zamboni M 2010 Age Ageing, 39 (4) 412-23