Revista da Associação Médica Brasileira

REFERÊNCIA

COSTA, Thais Ribeiro *et al*. Correlation of respiratory muscle strength with anthropometric variables of eutrophic and obese women. **Revista da Associação Médica Brasileira**, v. 56, n. 4, p. 403-408, 2010. DOI: https://doi.org/10.1590/S0104-42302010000400011. Disponível em: https://www.scielo.br/j/ramb/a/hhFxbRYBVWpXpNTyVX7btww/?lang=pt#. Acesso em: 10 jul. 2021.

Original Article

CORRELATION OF RESPIRATORY MUSCLE STRENGTH WITH ANTHROPOMETRIC VARIABLES OF NORMAL-WEIGHT AND OBESE WOMEN

Thais Ribeiro Costa[1*], **Tiago Pessoa Lima**[2], **Patrícia Lúcia Gontijo**[3], **Harley Alves de Carvalho**[4], **Flávia Perassa de Faria Cardoso**[5], **Orlando Pereira Faria**[6], **Florêncio Figueiredo Cavalcanti Neto**[7]

Study conducted at Universidade Católica de Brasília – UCB (Campus I), Brasília, DF, Brazil

ABSTRACT

Objective. To correlate anthropometric data and respiratory muscle strength (RMS) of normal-weight and obese women.

Methods. The sample consisted of 103 sedentary women, divided into two groups: 57 obese and 46 normal-weight women. Waist circumference (WC) and hip circumference (HC) were measured to calculate the waist-to-hip ratio (WHR), and maximal respiratory pressures (Pmax) were determined using an analog vacuum manometer to ± 300 cm H2O. Body composition was measured using tetrapolar bioelectrical impedance analysis. Descriptive statistics was used for data analysis, in addition to the Student t test for independent samples, Pearson correlation, and stepwise multiple linear regression analysis. Significance level was set at $p \leq 0.05$.

Results. The analysis showed significant differences in Pmax of normal-weight women (PImax = -73.04±16.55 cm H2O and PEmax = 79.67±18.89 cm H2O) and obese women (PImax = -85.00±21.69 cm H2O and PEmax = 103.86±20.35 cm H2O). Anthropometric and manometric variables showed no significant correlation in both groups. When analyzing the influence of bioelectrical impedance on RMS, a positive correlation was observed between lean body mass and PImax.

Conclusion. Bioelectrical impedance and obesity showed a direct correlation with RMS. WC and WHR had no influence on RMS of obese women; however, a relevance to risk factors for associated diseases was observed. We believe that these results are due to an adjustment to excess body weight over the years.

Key words: Obesity. Body composition. Respiratory muscles.

***Correspondence**
SMPW Quadra 17 Conjunto
13 Lote 01 Casa G - Park Way
Brasília-DF, Brazil
CEP: 71743-713
Phone: (+55 61) 8441-2220
tareides@gmail.com

Introduction

Obesity is a chronic noncommunicable disease (NCD), multifactorial in etiology, resulting from weight gain, caused by an energy imbalance between calories consumed on one hand, and calories expended on the other hand.[1] It is considered a public health problem due to impact factors leading to loss of quality of life as well as loss of life years.[1,2] Data from the World Health Organization (WHO) indicate that globally in 2005 approximately 1.6 billion adults (older than 15 years) were overweight and at least 400 million were obese.[3] Projections to 2015 indicate an increase in the number of overweight people to approximately 2.3 billion adults, and more than 700 million adults will be obese.[3] In Brazil, overweight and obesity have risen dramatically to epidemic proportions.4 Prospective studies indicate that Brazil is projected to rank fifth by the year 2025 in burden of obesity worlwide.[5]

Obese individuals are characterized by the distribution of body fat chiefly in the abdominal region, known as android obesity.[2,8] Abdominal adipose-tissue accumulation increases the risk of developing severe chronic and degenerative diseases such as type 2 diabetes, coronary diseases, musculoskeletal disorders, systemic hypertension, cerebrovascular accident, psychosocial problems, obstructive sleep apnea syndrome, and respiratory problems. Obesity may also be classified as gynecoid, which is characterized by the distribution of body fat chiefly in the region of the hips, thighs, and buttocks. It is more commonly observed in women and considered less harmful to health when compared to android obesity, giving rise mainly to aesthetic

---

1. Especialista em Terapia Intensiva e fisioterapeuta na Universidade Católica de Brasília – UCB, Brasília, DF
2. Pós-graduando em fisioterapia em terapia Intensiva; fisioterapeuta na Universidade Católica de Brasília - UCB, Brasília, DF
3. Graduada em fisioterapia pela Universidade Católica de Brasília - UCB e fisioterapeuta, Brasília, DF
4. Pós-graduado em fisioterapia na Universidade de Brasília - UnB e Fisioterapeuta, Brasília, DF
5. Doutoranda em Educação Física pela Universidade Católica de Brasília - UCB; fisioterapeuta e professora da graduação e coordenadora da pós-graduação em fisioterapia em terapia intensiva da Universidade de Brasília - UCB, Brasília, DF
6. Titular da Sociedade Brasileira de Cirurgia Bariátrica e diretor clínico da Gastrocirurgia Brasília e médico cirurgião, Brasília, DF
7. Pós-Doutorado pela Duke Medical Center - USA e World Health Organization- WHO – Suíça; professor orientador de doutorado e mestrado da Universidade Católica de Brasília - UCB e da Universidade de Brasília – UnB e secretário adjunto de Saúde/SES-DF e médico, Brasília, DF

issues.[1,2,7,8] In addition to these diseases, other studies show that obesity can also promote considerable changes in respiratory function: decreased functional residual capacity (FRC), tidal volume (TV), and lung compliance; disturbed ventilation-perfusion ratio (VA/Q); alveolar hypoventilation; carbon dioxide (CO2) retention and increased respiratory airflow resistance; and changes in the respiratory mechanics of the rib cage and diaphragm, increasing respiratory muscle workload.[2, 9, 10]

Respiratory muscle strength (RMS) can be measured by vacuum manometry and expressed as centimeters of water (cm $H2_2O$) through maximal respiratory pressures (Pmax).[11,13] Maximal inspiratory pressure (PImax) is the highest negative pressure that can be generated during inspiration and refers to ventilatory capacity.[13] Maximal expiratory pressure (PEmax) is the highest positive pressure achieved during forced expiration and, clinically, is crucial to produce an effective cough.[11-13]

The waist-to-hip ratio (WHR) is represented as the ratio between waist circumference (WC), measured at the midpoint between the lowest costal margin and the superior iliac crest, and hip circumference (HC), measured at the level of the greater trochanter of the femur.[14,18] After WHR is obtained, the distribution of body fat is established as either android or gynecoid.[17] Women with ratios greater than 0.85 and men with ratios greater than 0.90 have increased risk of developing obesity-related metabolic abnormalities, such as elevated blood pressure, impaired glucose tolerance, dyslipidemia, and insulin resistance.[19, 20] WC determines abdominal adiposity, and values greater than 80 cm in women and 94 cm in men indicate increased risk for chronic degenerative diseases.[17] Values above 88 cm for women and 103 cm for men can further increase the risk for metabolic complications.[17, 21]

Bioelectrical impedance describes the ability of a living organism to resist to passage of an electric current.[19] The device measures the passage of electric signals through lean tissues, fat, and water.[19,16] This method is based on the premise that electrical conductivity of hydrated fat-free tissue is greater than that of fat due to lower resistance to current flow. Thus, electric current flows easily through lean mass, whereas fat mass shows greater resistance to current flow due to low levels of water.[19, 16]

In order to contribute to further knowledge of the subject, with regard specifically to the recordings of reference values for RMS, this study aimed to conduct a quantitative analysis of data resulting from the interrelationship of variables, using matched normal-weight volunteers so that, in the future, better service, monitoring and physiotherapy treatment may be provided to a growing obese population.

OBJECTIVES

General objective

To correlate anthropometric data with RMS of normal-weight and obese women.

Specific objectives

To correlate Pmax with WHR and WC.

To verify the influence of body composition on RMS.

To evaluate body composition in both groups.

To identify which group has the highest RMS.

PATIENTS AND METHODS

The initial study population consisted of 108 women; three volunteers were excluded because they failed to complete the required tests and two volunteers because they were smokers. The final sample was then composed of 103 women, aged between 20 and 55 years. The participants were divided into two groups: obese women, with body mass index (BMI) ≥ 30 kg/m2 (study group, n = 57); normal-weight women, BMI 18.5-24.9 kg/m2 (control group, n = 46). All patients provided written informed consent. All participants were randomly selected according to inclusion and exclusion criteria established for both groups. The study was approved by the Research Ethics Committee of Universidade Católica de Brasília (UCB), Brazil (protocol no. 052/2009).

Study design

A cross-sectional study.

3.1.1. Inclusion criteria

Women aged 20 to 55 years.

BMI ≥ 30 kg/m^2 for the study group, and BMI 18.5-24.9 kg/m2 for the control group.

Women with no restrictions that could alter the rib cage or respiratory muscles.

Women who do not practice regular physical activity.

Exclusion criteria

Current smokers.

Patients with any physical or mental dysfunction that could hinder a proper understanding of the tests.

Patients with uncompensated associated diseases, such as heart diseases, metabolic disorders, lung diseases, and neuromuscular diseases.

Patients who failed to complete the proposed tests and/or did not meet the inclusion criteria.

METHODOLOGY

An evaluation form was filled out, on which were recorded the patient's personal data, associated diseases, life style, degree of dyspnea, vital signs, anthropometric measurements, and Pmax and bioelectrical impedance data.

The participants were previously instructed to wear light and comfortable clothes on the day of examination, to avoid heavy meals at least four hours prior to testing, to avoid caffeine-containing beverages and alcohol 24 hours prior to collection, and not to be in the premenstrual period.[15, 22, 23]

The volunteers remained seated and at rest for approximately 10 minutes. Heart rate and peripheral oxygen saturation (SpO_2) were measured by pulse oximetry (*Nonin-Onyx®*) and blood pressure was measured in the left upper limb using a stethoscope (*Littmann®*) eand a sphygmomanometer *(Missouri®)*.

Overweight and obesity in adult populations are estimated by BMI, which is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2).[1, 6] WHO defines overweight as a BMI ≥ 25 kg/m^2 and obesity as a BMI ≥ 30 kg/m^2.[1] Based on BMI values we can obtain a classification of obesity, as follows:[2,14] grade I – BMI 30-34.9 kg/m^2; grade II – BMI 35-39.9 kg/m^2; and grade III – BMI ≥ 40 kg/m^2. Other anthropometric methods are used in the evaluation, quantification, and distribution of fat, such as WHR, WC, and HC, which are often easy to apply and show a high degree of evidence.[17] Among the laboratory methods used to assess body composition, bioelectrical impedance has high specificity and sensitivity, in addition to a wide range of applications.[15, 16, 17]

A digital scale *(Filizola®)*, with capacity for 180 kg and accuracy of 100 g was used to measure body weight. Standing height was measured with a wall-mounted stadiometer accurate to 0.1 cm (*Cardiomed®*) in the same laboratory room used for collection. BMI was calculated after all data were collected using the equation weight/height^2.

WC was measured at the midpoint between the lowest costal margin and the superior iliac crest. HC was measured at the level of the greater trochanter of the femur. These measurements were performed with the volunteers in the upright position, breathing at FRC level, using a long flexible tape measure (*Kapor®*) wide by 13 mm and calibrated in millimeters.

Body composition was assessed using tetrapolar bioelectrical impedance analysis (*Biodynamics® model 310*) with volunteers in the supine position and their arms and legs in 45° of abduction. This method estimates in a direct manner lean body mass and percent body fat and water.[15] Four electrodes were used. The contact areas were cleaned with 70% alcohol and the electrodes were attached, as recommended by the manufacturer, at the following sites: emitters – dorsal surface of the right hand near the metacarpophalangeal joint and distal transverse arch of the upper surface of the right foot; collectors – posterior prominence of the distal radioulnar joint of the right wrist and between the medial malleolus and lateral malleolus of the right ankle.[15, 23]

Pressures were obtained by quantifying PImax and PEmax with the volunteer seated, wearing a nose clip to impede nasal airflow and a rigid and flat mouthpiece, held tightly between the lips, to prevent an increase in intraoral pressure.[12,24,25] The analog vacuum manometer ± 300cm H_2O (*Suporte®*) was connected to a 15-cm tracheal tube and a universal connector with a small orifice to relieve excess pressure, thus avoiding early glottic closure during PImax and reducing the use of facial muscles during PEmax.[12,18,24,25,26]

To quantify PImax the volunteer was instructed to perform a maximal inspiratory effort from residual volume (RV), and to quantify PEmax a maximal expiratory effort from total lung capacity (TLC), both against an occluded airway.[13, 26]

The test was conducted by experienced, previously trained researchers, who provided a brief explanation and demonstration to the participants on how to correctly perform the test. After the explanation, the volunteer was instructed to perform five maneuvers producing three acceptable measurements. The highest value obtained from the measurements was used for statistical analysis as long as this value was not the last one obtained. Maneuvers without air leaks and with sustained effort for at least one second were accepted, and measurements with variation less than or equal to 10% of the highest value were considered reproducible.[12,13,26] The time interval to rest between measurements was one minute.[12,13,26]

Statistical analysis

Descriptive statistics was used for data analysis with mean ± standard deviation and maximum and minimum values, in addition to the Student t test for independent samples, Pearson correlation, and stepwise multiple linear regression analysis.

Descriptive statistics was performed using Statistical Package for the Social Sciences (SPSS) version 10.0 to analyze and correlate anthropometric data and RMS in different degrees of obesity (grades I, II, and III). Significance level was set at $p \leq 0.05$.

RESULTS

The sample was composed of 103 women, 46 normal-weight and 57 obese women.

Comparative bioelectrical impedance analysis between groups showed significant differences in percent fat weight, total fat, and water ($p = 0.001$). Obese women had higher fat weight, amounts of water, and total fat than normal-weight women.

A significant difference in the percentage of lean mass was found between groups ($t[101] = 15.78$; $p = 0.001$); normal-weight women (73.86±4.29%) had a higher percentage of lean mass than obese women (61.29±3.79%).

When comparing manometric measurements between groups, the analysis revealed a significant difference in PImax and PEmax ($p = 0.001$). Obese women had higher manometric values than normal-weight women (Table 1).

Stepwise multiple linear regression analysis was conducted to determine the influence of body composition on Pmax of both obese and normal-weight women.

Lean mass had an influence on PImax of obese women ($p \leq 0.05$), and the other variables (percent fat weight, total fat, and water) were removed ($p \geq 0.05$), accepting the hypothesis that lean mass has an influence on Pmax.

A significant positive correlation was observed between the amount of lean mass and PImax, indicating that the greater the amount of lean mass in obese women, the greater the force generated by inspiratory muscles.

Bioelectrical impedance variables (lean mass, percent fat weight, total fat, and water) had no statistically significant influence on PEmax and Pmax of obese and normal-weight women, respectively.

DISCUSSION

The importance of using a control group for a reliable assessment of RMS has been reported in the literature, indicating that a comparison between obese and normal-weight subjects is more likely to reveal a positive correlation with Pmax values.[27] However, studies have employed different equations to predict or estimate Pmax, finding similar or lower values. [12,28]

In the present study, values found for bioelectrical impedance, WC, WHR, and Pmax were higher in obese women

Table 1 - Comparison of vacuum manometry between groups

	Normal-weight (n=46)	Obese (n=57)	Valor t	Valor p
PImax (cm H_2O)	- 73, 04 ± 16,55	- 85,00 ± 21,69	3,17	0,002*
PEmax (cm H_2O)	79,67 ± 18,89	103,86 ± 20,35	- 6,18	0,001*

* $p \leq 0.05$ is significant.

cm H2O = centimeters of water; PEmax = maximal expiratory pressure; PImax = maximal inspiratory pressure.

The analysis showed no correlation between anthropometric variables and vacuum manometry in normal-weight (Table 2) and obese (Table 3) women.

Table 2 - Correlation between anthropometry and vacuum manometry in normal-weight women (n = 46)

	PImax		PEmax	
	r	p	r	p
WC (cm)	- 0,04	0,82	0,06	0,72
WHR	0,08	0,60	0,10	0,53

* $p \leq 0.05$ is significant.

PEmax = maximal expiratory pressure; PImax = maximal inspiratory pressure; WC = waist circumference; WHR = waist-to-hip ratio.

Table 3 - Correlation between anthropometry and vacuum manometry in obese women (n = 57)

	PImax		PEmax	
	r	p	r	p
WC (cm)	- 0,12	0,37	0,14	0,29
WHR	0,11	0,40	0,22	0,11

* $p \leq 0.05$ is significant.

PEmax = maximal expiratory pressure; PImax = maximal inspiratory pressure; WC = waist circumference; WHR = waist-to-hip ratio.

compared to normal-weight women, all with a significant p value.

Cardoso [29] studied 33 grade II and III obese women, candidates for bariatric surgery, and observed that RMS, although higher, showed no statistically significant difference when compared to normative data for the Brazilian population established by Neder et al..[12] Domingos-Benício et al.[30] found similar RMS values between groups of obese and normal-weight subjects, separated by BMI and not by sex.

Magnani and Cataneo,[18] in a study only with obese individuals aged 20-64 years, verified that obesity does not impair RMS, since Pmax values did not achieve significance when compared with reference values for normality established by Neder et al..[12]

Queiroz [25] conducted a study with obese and nonobese individuals (n = 100) separated by sex. The author evaluated Pmax of these groups and found that the obese group, regardless of sex, had higher RMS than nonobese subjects. The present study, which also has a control group, found similar values with $p < 0.001$.

Our statistical analysis correlating WHR with RMS revealed no significant results, which are consistent with previous findings.[18,25]. Magnani and Cataneo[18] reported that obesity did not interfere with RMS at any age group and degree of obesity, respectively. High WC and WHR measurements appeared not to compromise RMS of women in that study.

In the analysis of WC and WHR data, increased values were found for obese women compared to normal-weight women. These data corroborate the findings by Martins et al.,[31] who described a positive correlation between WC and WHR in the obese group, associating these results with socioeconomic, behavioral, and biochemical risk factors that play a role in the etiology of central obesity.

The literature describes that values above 80 cm for WC and 0.85 cm for WHR are associated with higher incidence of obesity-related diseases.[14,17,21] Our data showed increased WC and WHR values (112.86±13.86 and 0.91±0.08 cm, respectively), and the percentage of diseases found was 26.3% for hypertension, 24.6% for high cholesterol levels, and 7% for diabetes. These findings are consistent with the strong correlation between WC and risk factors for associated diseases described in the literature.[1,2,8,31] Muscles of obese individuals have specific histological and metabolic characteristics, showing an increase in lean mass and a more powerful muscle contraction. Due to daily physical efforts to move the body and attempts of the musculoskeletal structure to maintain the body in the upright position, obese individuals have a higher proportion of skeletal muscle mass and type II fibers.[32] Tanner et al.[22] investigated the type of muscle fiber present in obese subjects, by means of a biopsy of the rectus abdominus during bariatric surgery, and found a high percentage of type II fibers, which are related to low endurance and high power to perform physical activities.

According to Cezar,[32] in a review of the literature about characteristics of the obese population regarding body composition, these individuals have the proportion of lean mass increased by the physical effort required to move the body, thus showing more type II fibers.

In the present study, the results from bioelectrical impedance analysis revealed that the percentage of lean body mass was higher in normal-weight women compared to obese women ($p < 0.001$), with a positive correlation between lean mass and PImax of obese women ($p < 0.05$).

The study by Rolland et al.[33] of 1454 women, 215 were obese, verified that handgrip strength is directly related to overall muscle strength, inferring a positive association with RMS, which is consistent with the findings by Queiroz.[25]

Thus, these studies add to and strengthen our data, confirming that obese women are stronger and show higher RMS (with a significant p value), which might have occurred due to a probable adaption of muscle fibers.

CONCLUSION

We can conclude that obese women have higher respiratory muscle strength compared to normal-weight women, either by adaptation to obesity over the years or by respiratory muscle overload imposed to the diaphragm, or even by changes in muscle fiber type.

These patients should undergo examinations that assess body composition, since a positive correlation was found between these variables and respiratory muscle strength, demonstrating that such analysis can be used to correlate parameters.

Despite not interfering with respiratory muscle strength, waist circumference should be always assessed in these women, since there is a strong association of this measurement with obesity-related diseases, increasing even further the risk factors for cardiovascular and metabolic diseases.

A significant positive correlation was found between the amount of lean mass and PImax in obese women, indicating that the greater the amount of lean mass, the greater the respiratory (inspiratory) muscle strength.

Nevertheless, further studies involving more patients should be conducted, separating degrees of obesity and using other methods of body composition assessment.

Conflict of interest: No conflicts of interest declared concerning the publication of this article.

REFERENCES

1. Organização Mundial de Saúde (OMS). Obesity and overweight. N°311; Sept 2006. [cited 2008 oct 14]. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/index.html.
2. Teixeira CA, Santos JE, Silva GA, Souza EST, Martinez JAB. Prevalência de dispnéia e possíveis mecanismos fisiopatológicos envolvidos em indivíduos com obesidade graus 2 e 3. J Bras Pneumol. 2007;33(1):28-35.
3. Organização Mundial de Saúde (OMS). Conferência Ministerial Européia de Luta contra Obesidade, Istambul 15-17 November 2006 .WHO/EUROPE. [cited 2008 jun 18]. Available from: http://www.euro.who.int/obesity/import/20060217_1.
4. IBGE. Pesquisa de Orçamentos Familiares (POF) e Ministério da Saúde, 2002-2003. [citado 24 nov 2008]. Disponível em: www.ibge.org.br.
5. Teixeira L, Zanesco A, De Moraes C. Obesidade e asma. In: Damaso A. Obesidade. Rio de Janeiro: Medsi; 2003. p.135-52.
6. Organização Mundial de Saúde/Organização Pan-Americana de Saúde. Doenças crônico-degenerativas e obesidade: estratégia mundial sobre a alimentação saudavél, atividade física e saúde. Brasília (DF); 2003. p.27-34.
7. Pottier MS, Oyama LM, Nascimento CMO. Obesidade e dislipidemia. In: Damaso A. Obesidade. Rio de Janeiro: Medsi; 2003. p.54-63.
8. Pinheiro ARO, Freitas SFT, Corso ACT. Uma abordagem epidemiológica da obesidade. Rev Nutr. 2004;17(4):523-33.
9. Rasslan Z, Junior RS, Stirbulov R, Fabbri RMA, Lima CAC. Avaliação da função pulmonar na obesidade graus I e II. J Bras Pneumol. 2004;30(6):508-14.
10. Rigatto AM, Alves SCC, Gonçalves CB, Firmo JF, Provin LM. Performance ventilatória na obesidade. Saúde Rev. 2005;7(17):57-62.
11. Karvoneri J, Saarelainen SS, Nieminen MM. Measurement of respiratory muscle force based on maximal inspiratory and expiratory pressure. Respiration. 1994;61(1):28-31.
12. Neder JA, Andreoli S, Lerario MC, Nery LE. Reference values for lung function tests. II. Maximal respiratory pressures and voluntary ventilation. Braz J Med Biol Res. 1999;32(6):719-27.
13. Souza RB. Pressões respiratórias estáticas máximas. J Bras Pneumol. 2002; 28 (Supl 3):155-64.
14. Organização Mundial de Saúde (OMS). The World Health Report, 2002. Reducing risks, promoting healthy life. [cited 2009 feb 23]. Available from: http://www.who.int/whr/2002/en/whr02_en.pdf.
15. Segal KR, Loan MV, Fitzgerald PI, Hodgdon JA, Van Itallie TB. Lean body mass estimation by bioelectrical impedance analysis: a four-site cross validation study. Am J Clin Nutr. 1988;47(6):7-14.
16. Rodrigues MN, Silva SC, Farinatti PTV. Estimativa da gordura corporal através de aparelhos de bioimpedância, dobras cutâneas e pessagem hidroestática. Rev Bras Med Esporte. 2001;7(4):125-31.
17. Dâmaso A, Bernardes D. Avaliação Antropométrica e da composição corporal. In: Damaso A. Obesidade. Rio de Janeiro: Medsi; 2003. p.352-66.
18. Magnani KL, Cataneo AJM. Respiratory muscle strength in obese individuals and influence of upper-body fat distribution. São Paulo Med J. 2007;125(4): 215-9.
19. Ellis KJ. Human body composition: in vivo methods. Physiol Rev. 2000;80(2): 649-80.
20. Radominski RB. Outros métodos de determinação de composição corporal nos obesos. Arq Bras Endocrinol Metabol. 2001;45(4):276-9.
21. Ochs-Balcom HM, Grant BJ, Muti P; Sempos CT, Trevisan M, Cassano PA, et al. Pulmonary function and abdominal adiposity in the general population. Chest. 2006;129(4):853-62.
22. Tanner CJ, Barakat HA,.Dohm GL, Pories WJ, Mac Donald KG, Cunningham PR, et al. Muscle fiber type is associated with obesity and weight loss. Am J Physiol Endocrinol Metab. 2002;282(6):1191-6.
23. Marques MB, Heyward V, Paiva CE. Validação cruzada de equações de bioimpedância em mulheres brasileiras por meio de absortometria radiológica de dupla energia (DXA). Rev Bras Ciênc Mov. 2008;8(4):14-20.
24. American Thoracic Society; European Respiratory Society. ATS/ERS Statement on respiratory muscle testing. Am J Respir Crit Care Med. 2002;166(4):518-624.
25. Queiroz, J.C.F. Correlação entre a força de pressão palmar e a força da musculatura respiratória em indivíduos obesos e não-obesos [dissertação]. Brasília (DF): Universidade Católica de Brasília; 2006.

26. Parreira VF, França DC, Zampa CC, Fonseca MM, Tomich GM, Britto RR. Pressões respiratórias máximas: valores encontrados e preditos em indivíduos saudáveis. Rev Bras Fisioter. 2007;11(5):361-8.
27. Gibson GJ. Obesity, respiratory function and breathlessness. Thorax. 2000; 55(Suppl 1):41-4.
28. Black, L.F.; Hyatt, R.E. Maximal respiratory pressures: normal values and relationship to age and sex. Am Rev Respir Dis. 1969;99(5):696-702.
29. Cardoso FPF. Manovacuometria e ventilometria de mulheres obesas no pré-operatório de gastroplastia redutora [dissertação]. Brasília (DF): Universidade Católica de Brasília; 2005.
30. Domingos-Benício NC, Gastaldi AC, Perecini JC, Avena KM, Guimarães RC, Sologuren MJJ, et al. Influência do peso corporal sobre as pressões respiratórias máximas nas posições sentada, deitada e em pé. Rev Bras Fisioter. 2003;7(3):217-22.
31. Martins IS, Marinho SP. O potencial diagnóstico dos indicadores da obesidade centralizada. Rev Saúde Pública. 2003;37(6):760-7.
32. Cezar C. Limitações metodológicas e dificuldades práticas para avaliação da composição corporal em obesidade moderada e grave. Rev Bras Nutr Clin. 2002;1(4):143-8.
33. Rolland Y, Lauwers-Cances V, Pahor M, Fillaux J, Grandjean H, Vellas B. Muscle strength in obeses elderly women: effect of recreational physical activity in a cross-sectional study. Am J Clin Nutr. 2004;79(4):552-7.

Artigo recebido: 3/11/10
Aceito para publicação: 5/5/10