



Revista da ASSOCIAÇÃO MÉDICA BRASILEIRA

www.ramb.org.br



Original article

Lung age in women with morbid obesity[☆]

Fabiana Sobral Peixoto-Souza^a, Camila Piconi-Mendes^a, Letícia Baltieri^a,
Irineu Rasera-Junior^b, Marcela Cangussu Barbalho-Moulim^c,
Maria Imaculada de Lima Montebelo^a, Dirceu Costa^d, Eli Maria Pazzianotto-Forti^{a,*}

^a Department of Physiotherapy, Universidade Metodista de Piracicaba (UNIMEP), Piracicaba, SP, Brazil

^b Centro de Gastroenterologia e Cirurgia da Obesidade Piracicaba, Piracicaba, SP, Brazil

^c Department of Physiotherapy, Universidade Federal de São Carlos (UFSCar), São Carlos, SP, Brazil

^d Department of Physiotherapy, Universidade Nove de Julho (UNINOVE), São Paulo, SP, Brazil

ARTICLE INFO

Article history:

Received 1 October 2012

Accepted 30 December 2012

Available online 16 May 2013

Keywords:

Morbid obesity

Women

Spirometry

Respiratory function tests

ABSTRACT

Objective: To investigate the influence of morbid obesity on the lung age in women and to correlate with body mass, body mass index (BMI), and ventilatory variables.

Methods: This was a cross-sectional study with 72 morbidly obese women and a control group consisting of 37 normal weight women. The subjects performed a pulmonary function test to determine lung age, and the results were correlated to anthropometric variables and lung volumes.

Results: The morbidly obese group had significantly higher lung age (50.1 ± 6.8 years) than the control group (38.8 ± 11.4 years). There was no difference in chronological age between groups. There was a significant positive correlation among chronological age, body mass, BMI, and lung age ($r = 0.3647, 0.4182, \text{ and } 0.3743$, respectively). There was a negative correlation among forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC ratio, expiratory reserve volume (ERV), and lung age ($r = -0.7565, -0.8769, -0.2723, \text{ and } -0.2417$, respectively).

Conclusion: Lung age is increased in morbidly obese women and is associated with increased body mass and BMI.

© 2013 Elsevier Editora Ltda. All rights reserved.

Idade pulmonar em mulheres com obesidade mórbida

RESUMO

Objetivo: Verificar a influência da obesidade mórbida na idade pulmonar de mulheres e correlacionar com a massa corporal, índice de massa corporal (IMC) e variáveis ventilatórias. **Métodos:** Estudo longitudinal realizado com 72 obesas mórbidas e grupo controle constituído de mulheres eutróficas. As voluntárias realizaram um teste de função pulmonar para determinação da idade pulmonar e os resultados foram correlacionados com as variáveis antropométricas e volumes pulmonares.

Palavras-chave:

Obesidade mórbida

Mulher

Espirometria

Testes de função respiratória

[☆] Study conducted at Universidade Metodista de Piracicaba, Piracicaba, SP, Brazil.

* Corresponding author: Rodovia do Açúcar Km 156, Taquaral, Bloco 7, Sala 33, Piracicaba, SP, 13400-911, Brazil.

E-mail: empforti@unimep.br (E.M. Pazzianotto-Forti).

0104-4230/\$ – see front matter © 2013 Elsevier Editora Ltda. All rights reserved.

<http://dx.doi.org/10.1016/j.ramb.2012.12.010>

Resultados: As obesas mórbidas apresentaram uma idade pulmonar significativamente superior ($50,1 \pm 6,8$ anos) às eutróficas ($38,8 \pm 11,4$ anos). Não houve diferença entre a idade cronológica entre os grupos. Houve uma correlação significativa e positiva entre idade cronológica, massa corporal e IMC com a idade pulmonar ($r = 0,3647, 0,4182, 0,3743$, respectivamente). Houve uma correlação negativa entre a capacidade vital forçada (CVF), volume expiratório forçado no primeiro segundo (VEF₁), razão (VEF₁/CVF) e volume de reserva expiratório (VRE) com a idade pulmonar ($r = -0,7565, -0,8769, -0,2723, -0,2417$, respectivamente).

Conclusão: A idade pulmonar das obesas mórbidas encontra-se aumentada e está associada com o aumento da massa corporal e IMC.

© 2013 Elsevier Editora Ltda. Todos os direitos reservados.

Introduction

According to the World Health Organization, obesity is considered a public health problem of alarming proportions worldwide. It has been predicted for 2015 that approximately 2.3 billion adults will be overweight, and that over 700 million will be obese.¹ In Brazil, 48.5% of the population is overweight, of which 15.8% is classified as obese.²

Obesity is considered a relevant risk factor for cardiovascular disease, diabetes mellitus type 2, rheumatoid arthritis, and cancer.³⁻⁵ It is also recognized as an important risk factor for developing respiratory diseases, such as hypoventilation syndrome and sleep apnea, as well as for the reduction in lung volumes.⁶

Reports on changes in lung function in obesity point to mechanical and inflammatory changes as major factors. The inflammatory effects are due to the secretion of inflammatory adipokines by adipose tissue. These adipokines regulate the inflammatory system, which is associated with changes in lung function.^{7,8} The mechanical effects are attributed to increased abdominal pressure and decreased chest wall compliance caused by excessive fat tissue in these regions.^{9,10}

Equations were developed from linear regression to estimate lung age, considering the ventilatory function obtained through spirometry. Research has shown that forced expiratory volume in the first second (FEV₁) is the best variable for mathematically calculating lung age¹¹ in order to compare it with the individual's chronological age, as a marker for the individual's awareness of the dangers of smoking in studies related to lung disease and smoking.¹²

Taking under consideration that the literature has few studies of lung age in relation to obesity, while at the same time many studies point to changes in lung function in this population, the hypothesis of this study is that morbidly obese women may have an early pulmonary aging compared to normal weight women.

Since morbid obesity leads to several comorbidities and reduced quality of life, strategies must be designed to combat this disease through awareness of its harm to health. Thus, the aim of the present study was to investigate the influence of morbid obesity in women's lung age, and to correlate lung age with body mass, BMI, and ventilatory variables.

Methods

Population studied

This was a cross-sectional study, in which 109 adult women were studied, divided into two parallel groups: 72 obese women (age: 34.6 ± 6.8 years, BMI: 45.8 ± 5.4 kg/m²), and a control group of 37 normal weight women (age: 34.9 ± 7.6 years, BMI: 22.7 ± 1.9 kg/m²). The volunteers were informed about the objective of the study and signed an informed consent. The study was approved by the ethics committee under protocol n 19/10.

The morbidly obese women were screened in a bariatric clinic in the city of Piracicaba, São Paulo, Brazil, where they met with the multidisciplinary team to prepare for bariatric surgery. The control group was recruited in the community by invitation to participate in research.

The inclusion criteria were: women with morbid obesity (40 kg/m² \leq BMI \leq 55 kg/m²) and normal weight women (18.5 kg/m² \leq BMI \leq 24.9 kg/m²); age between 25 and 50 years; caucasian; sedentary with scores up to 8, according to the Baecke Questionnaire,¹³ which was validated in Brazil by Florida and Latorre;¹⁴ without the presence of comorbidities such as hypertension, diabetes, cardiovascular or pulmonary disease; nonsmokers or ex-smokers; and understanding of spirometric maneuvers.

Procedures

Initially, data pertinent to the clinical history, anthropometry, and assessment of lung volumes and capacities were performed by spirometric test.

Anthropometrics data

The subjects stood without shoes or heavy clothes. Body weight was measured by a digital scale (Filizola® - Brazil) calibrated with a maximum capacity of 300Kg, and resolution of 100 grams. Height was assessed by a wall stadiometer. The BMI was obtained by the equation weight/height² (kg/m²).

Table 1 – Age, anthropometrics, and spirometric characteristics of normal weight and morbidly obese women.

Variables	Normal weight (n=37)	Morbidly obese (n=72)	p-value
Chronological age (years)	34.9 ± 7.6	34.6 ± 6.8	0.58
Height (m)	1.6 ± 5.6	1.6 ± 5.9	0.5751
Body weight (kg)	58.9 ± 6.1	119.5 ± 14.4	< 0.0001
BMI (kg/m ²)	22.7 ± 1.9	45.8 ± 5.4	< 0.05
FVC (L)	3.5 ± 0.4	3.28 ± 0.5	0.0076
FVC (% predicted)	103.1 ± 9.6	96.0 ± 13.1	0.0023
VEF ₁ (L)	3.1 ± 0.4	2.8 ± 0.4	0.0006
FEV ₁ (%)	106.8 ± 11.4	96.3 ± 12.3	< 0.0001
predicted)			
FEV ₁ /FVC (%)	102.1 ± 7.0	100.1 ± 6.3	0.03
predicted)			
ERV (L)	0.8 ± 0.3	0.5 ± 0.4	0.0005

Values expressed as mean and standard deviation. BMI, body mass index; FVC, forced vital capacity; FEV₁, forced expiratory volume in the first second; FEV₁/FVC, ratio of FEV₁ to FVC; ERV, expiratory reserve volume.

Spirometry

Spirometry was performed by computerized spirometer ultrasonic flow sensor (Microquark, Cosmed – Rome, Italy), calibrated daily before each test, following the standards recommended by the American Thoracic Society¹⁵ and the guidelines for testing lung function.¹⁶ All tests were performed in the morning to avoid circadian influences. The volunteers were instructed to remain seated and to use a nose clip during the maneuvers.

Slow vital capacity (SVC) and forced vital capacity (FVC) maneuvers were performed. Time-volume and volume-flow curves were performed according to the criteria for acceptability and reproducibility recommended by the guidelines for pulmonary function tests,¹⁶ in which the values for FEV₁ and FVC should differ less than 0.15 liters. Subsequently, it was calculated the highest value of FVC and FEV₁. The values were expressed in liters and in percentage of predicted, according to established values for the Brazilian population.¹⁷

Calculation of the estimated lung age

The calculation of lung age was based on estimates developed by Newbury et al.¹¹ (2010), which can be automatically generated by adjusting the settings of the spirometer, or calculated following the mathematical formula:

$$\text{Lung age} = 1.33 \times \text{height (cm)} - 31.98 \times \text{FEV}_1 \text{ obtained} - 74.65$$

Statistical analysis

After verifying the normality of the data by Lilliefors test, paired Student's t-test for parametric data and Wilcoxon test for nonparametric data were used to compare intra-group. For comparison between groups, Student's t-test for unpaired parametric data and the Mann-Whitney test for nonparametric data were performed.

Table 2 – Comparison between pulmonary and chronological age normal weight and morbidly obese women.

	Normal weight	Morbidly obese	p-value
Chronological age (years)	34.9 ± 7.6	34.6 ± 6.8	0.58
Lung age (years)	38.8 ± 11.4	50.1 ± 14.2	< 0.0001
Lung age - chronological age	3.9 ± 12.3	15.5 ± 12.3	< 0.0001

Values expressed as mean and standard deviation.

Pearson's correlation for parametric variables and the Spearman correlation for nonparametric variables were used for the correlation analysis of lung age with chronological age, anthropometrics, and lung volume.

The level of statistical significance was set at $p < 0.05$. All statistical procedures were performed using the statistical program BioStat version 5.0.

Results

There were no statistical differences in chronological age between the groups (Table 1). Body weight and BMI were significantly higher in morbidly obese than in normal weight women. Regarding spirometric values, it was observed that FVC, FEV₁, FVC/FEV₁, and expiratory response volume (ERV) were significantly lower in the morbidly obese group.

There was no difference in chronological age between groups (Table 2). The results of the comparison between chronological age and lung age show a significantly higher lung age (50.1 ± 14.2 years) in the morbidly obese group, with a difference of 15.5 ± 12.3 years. There was no difference between chronological age (34.6 ± 7.6 years) and lung age (38.8 ± 11.4 years) in the normal weight group.

Lung age was positively correlated to chronological age, body mass and BMI (Table 3). Lung age was negatively correlated to obtained and predicted FVC, FEV₁, FEV₁/FVC ratio, and ERV.

Table 3 – Correlation among lung age, pulmonary volumes, and anthropometric data of morbidly obese and normal weight women.

Lung age vs	Coefficient of correlation (r)	p-value
Chronological age	0.3647	< 0.0001
Body weight (kg)	0.4182	< 0.0001
BMI (kg/m ²)	0.3743	< 0.0001
FVC (L)	-0.7565	< 0.0001
FVC (%P)	-0.7449	< 0.0001
FEV ₁ (L)	-0.8769	< 0.0001
FEV ₁ (%P)	-0.8789	< 0.0001
FEV ₁ /FVC (%P)	-0.2723	0.0043
ERV (L)	-0.2417	0.0117

Values expressed as mean and standard deviation.

BMI, body mass index; FVC, forced vital capacity obtained; FVC, forced vital capacity; FEV₁, forced expiratory volume in the first second; FEV₁/FVC, ratio of FEV₁ to FVC; ERV, expiratory reserve volume.

Discussion

The concept of lung age was established with the objective of becoming a tool of awareness of damages that smoking causes to the lung, leading to premature aging of the organ. More recently, the calculation of lung age has been validated for detection of abnormalities caused by lung diseases.¹⁸ Parkes et al.¹⁹ conducted a study with 561 smokers with age up to 35 years, and found that telling smokers their lung age significantly improved the probability of an individual to quit smoking.

Studies show that obese subjects have higher levels of biomarkers of oxidative stress. The chronic oxidative stress in obesity promotes the development of organ lesions, such as cardiovascular disease and airway changes with reduced lung function.²⁰

The measurement of lung age suggests an identification of the pulmonary impairment of individuals with morbid obesity before they present spirometric or respiratory disorders.

FEV₁ is a powerful predictor of mortality and morbidity in general, lung diseases, cardiovascular diseases, and cancers.⁶ Studies show that weight gain is associated with reduced FEV₁ and vital capacity (VC), predisposing obese individuals to long-term adverse effects comparable to smoking, respiratory infections, and occupational and environmental exposures.^{21,22}

However, although obesity is a known predictor of reduction in FEV₁ and FVC and of increased lung age, an appropriate program for losing excess weight not only improves lung function but also causes a reduction in lung age.²³

Thus it is important to study the lung age of morbidly obese with no signs of cardiac or pulmonary disease, and to educate these individuals on the importance of weight loss, changes in habits, and greater adherence to treatment seeking weight reduction, before the installation of respiratory diseases that may contribute to a worsening of health and quality of life.

In the present study, an increased lung age of 11.3 years was observed in morbidly obese women compared to normal weight women; no difference was observed in chronological and lung age in the normal weight group.

The formula used to predict the lung age in this study was established by Newbury et al.,¹¹ whose study aimed to compare the lung age of a group of 340 nonsmokers and 50 smokers with the original formula established by Morris and Temple.¹² Newbury et al.¹¹ found that the formula established by Morris underestimated the lung age of smokers and nonsmokers in approximately two decades, and thus proposed the new formula.

Melo et al.²⁴ also found an increase of almost a decade in lung age in the morbidly obese group, even though they used the formula by Morris and Temple.¹²

Pulmonary aging related to obesity was also observed in the study by Mitsumune et al.,²⁵ which investigated the relationship among lung age, cigarette smoking, and BMI, and verified that a higher BMI was significantly associated with older lung age, regardless of cigarette addiction. However, in their study, obese people were considered as those with a BMI equal to or greater than 25 kg/m², according to the classification of obesity

by the Japanese Respiratory Society, which differs from that of the World Health Organization.

In the present study, there was a positive correlation between lung age and chronological age. As age increases, structural changes occur in the lung parenchyma and airways, as well as in the rib cage and respiratory muscles. There is an increase in FVC and FEV₁ until approximately age 20 years for women, and it diminishes with age, declining around 20 mL per year in subjects aged 25 to 39 years. This decline occurs gradually up to 65 years, when a reduction of around 38 mL per year begins.²⁶

In the present study, there was a positive correlation among lung age, body mass, and BMI. A correlation of lung age with BMI was also observed by Melo et al.²⁴ With exception of this last study, the association between aging of the lung and anthropometrics variables was not found in the literature. Most studies have sought to relate anthropometric variables and lung volumes, thus the importance of the present study for people with morbid obesity is emphasized.

There was a significant negative correlation between lung age and ERV. Moreover, this variable was found reduced compared with the control group. Regarding pulmonary function, it is well known that the greatest predictor of obesity is due to the reduction of ERV, leading to a reduction in functional residual capacity (FRC). This is due to cranial displacement of the diaphragm by abdominal obesity and weight gain of the chest wall. ERV reduces exponentially increasing BMI.²⁷

The concept of lung age, when added to spirometric results, is a new alternative understanding of lung damage caused by obesity, and provides a simple, easy, and straightforward interpretation. For obese patients, the calculation of lung age can be an instrument to promote greater adherence to weight loss programs, since the results of spirometry may not be well understood.²⁴

It can be concluded that the lung age observed in the morbidly obese group gives increased evidence of early lung aging in this population, and it is associated with increased body mass and BMI. The calculation of lung age can be recommended for morbidly obese patients to demonstrate the pulmonary complications of obesity, to motivate changes in lifestyle, and to emphasize the need for programs of weight reduction.

Conflict of interest

The authors declare to have no conflict of interest. The date of approval of the Ethics and Research, Methodist University of Piracicaba was 27/04/2010, under No. 19/10.

Acknowledgements

The authors would like to thank National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq), and Coordination for the Improvement of Higher Level Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES/PROSUP) for their contribution and support.

REFERENCES

1. WHO. World Health Organization. Obesity and overweight. 2006 [cited 2011 Mar 20]. Available from: <http://www.who.int/mediacentre/factsheets/fs311/en/>
2. Brasil. Ministério da Saúde. Doenças ligadas à obesidade custam R\$ 488 milhões [cited 22 Mar 2013]. Available from: <http://portalsaude.saude.gov.br/portalsaude/noticia/9905/162/doencas-associadas-a-obesidade-custam-meio-bilhao-de-reais.html>
3. McClean KM, Kee F, Young IS, Elborn JS. Obesity and the lung: epidemiology. *Thorax*. 2008;63:649-54.
4. Murugan AT, Sharma G. Obesity and respiratory diseases. *Chronic Respir Dis*. 2008;5:233-42.
5. Conway B, Rene A. Obesity as a disease: no lightweight matter. *Obesity Reviews*. 2004;5:145-51.
6. Knuiman MW, James AL, Divitini ML, Musk AW, Ryan G, Bartholomew HC. Lung function respiratory symptoms and mortality: results from the Busselton Health Study. *Annals of Epidemiology*. 1999;9:297-306.
7. Fogarty AW, Jones S, Britton JR, Lewis SA, McKeever TM. Systemic inflammation and decline in lung function in a general population: a prospective study. *Thorax*. 2007;62:515-20.
8. Thyagarajan B, Smith LJ, Barr RG, Sood A, Kalhan R, Jacobs Jr DR. Association of circulating adhesion molecules with lung function: The CARDIA Study. *Chest*. 2009;135:1481-7.
9. Collins CL, Hoberly PD, Walker JF, Fletcher EC, Peiris AN. The effects of body fat distribution on pulmonary function tests. *Chest*. 1995;107:1298-302.
10. Forti E, Ike D, Barbalho-Moulim M, Rasera JRI, Costa D. Effects of chest physiotherapy on the respiratory function of postoperative gastroplasty patients. *Clinics*. 2009;64:683-9.
11. Newbury W, Newbury J, Briggs N, Crockett A. Exploring the need to update lung age equations. *Prim Care Respir J*. 2010;13:242-7.
12. Morris JF, Temple W. Spirometric. lung age" estimation for motivating smoking cessation. *Preventive Medicine*. 1985;14:655-62.
13. Baecke JA, Burema J, Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *American Journal of Clinical Nutrition*. 1982;36:936-42.
14. Florindo AA, Latorre MRDO. Validação do questionário e reprodutibilidade de Baecke de avaliação da atividade física habitual em homens adultos. *Rev Bras Med Esporte*. 2003;121-8.
15. ATS/ERS., Task Force. Standardisation of lung function testing. Standardisation of spirometry. *European Respiratory Journal*. 2005;26:319-38.
16. Pereira CAC. Directives for pulmonary function tests. *J Pneumol*. 2002;28:1-82.
17. Pereira CAC, Barreto SP, Simões JG, Pereira FWL, Gerstler JG, Nakamura J. Valores de referência para espirometria em uma amostra da população brasileira adulta. *J Pneumol*. 1992;18:10-22.
18. Toda R, Hoshino T, Kawayama T, Imaoka H, Sakazaki Y, Tsuda T, et al. Validation of "lung age" measured by spirometry and handy electronic FEV1/FEV6 meter in pulmonary diseases. *Internal Medicine*. 2009;48:513-21.
19. Parkes G, Greenhalgh T, Griffin M, Dent R. Effect on smoking quit rate of telling patients their lung age: the Step2quit randomised controlled trial. *BMJ*. 2008;336:598-600.
20. Fitzpatrick A, Holguin F. Obesity, asthma, and oxidative stress. *Journal of Applied Physiology*. 2010;108:754-9.
21. Bottai M, Pistelli F, Di Pede F, Carrozzi L, Baldacci S, Matteelli G, et al. Longitudinal changes of body mass index, spirometry and diffusion in a general population. *European Respiratory Journal*. 2002;20:665-73.
22. Womack CJ, Harris DL, Katzel LI, Katzel LI, Hagberg JM, Bleecker ER, et al. Weight loss not aerobic exercise. Improves pulmonary function in older obese men. *Journals of Gerontology Series A, Biological Sciences and Medical Sciences*. 2000;55:453-7.
23. Quanjer PH, Enrigh PL. Should we use 'lung age'? *Prim Care Respir J*. 2010;19:197-9.
24. Melo SMD, De Melo VA, De Melo EV, Menezes Filho RS, De Castro VL, Barreto MSP. Accelerated lung aging in patients with morbid obesity. *J Bras Pneumol*. 2010;36:746-52.
25. Mitsumune T, Senoh E, Nishikawa H, Adachi M, Kajii E. The effect of obesity and smoking status on lung age in Japanese men. *Respirology*. 2009;14:757-60.
26. Janssens JP, Pache JC, Nicod LP. Physiological changes in respiratory function associated with ageing. *European Respiratory Journal*. 1999;13:197-205.
27. Jones RL, Nzekwu MMU. The effects of body mass index on lung volumes. *Chest*. 2006;130:827-33.