Respiratory muscle strength: Comparison between primigravidae and nulligravidae*

Força muscular respiratória: Comparação entre primigestas e nuligestas

Andrea Lemos, Ariani Impieri Souza, Armele Dornelas de Andrade, José Natal Figueiroa, José Eulálio Cabral-Filho

Abstract

Objective: To describe and to compare MIP and MEP in primigravidae and nulligravidae in the 20-29 year age bracket and paired by age. **Methods:** We included 120 primigravidae with low obstetric risk (5th-40th week of gestation) and 40 nulligravidae. All of the participants were of normal weight and none exercised regularly. All were recruited from the metropolitan area of Recife, Brazil. Measurements of MIP and MEP were obtained from RV and TLC, respectively, with a digital manometer. We used Student's t-test to compare the two groups, and we used multiple linear regression in order to determine whether group or chronological age correlated with MIP or MEP. **Results:** In the primigravida and nulligravida groups, the mean MIP values were 88.50 ± 16.52 cmH_2O and 94.22 ± 22.63 cmH_2O, respectively, (p = 0.08), whereas the mean MEP values were 99.76 ±18.19 cmH_2O and 98.67 ± 20.78 cmH_2O (p = 0.75). Gestational age did not correlate with MIP (r = −0.06; p = 0.49) or MEP (r = −0.11; p = 0.22). The relationship between chronological age and MIP/MEP did not differ between primigravidae and nulligravidae (angular coefficient = 0.028 and 0.453, respectively). **Conclusions:** Within this sample of women in the 20-29 year age bracket, the respiratory pressures of primigravidae remained stable during pregnancy and did not differ significantly from those of nulligravidae.

Keywords: Pregnancy; Respiratory function tests; Muscle strength.

Resumo

Objetivo: Descrever e comparar os valores de PImáx e de PEmáx em primigestas e nuligestas na faixa etária de 20-29 anos pareadas por idade. **Métodos:** Foram estudadas 120 primigestas de baixo risco obstétrico, da 5ª a 40ª semana gestacional, e 40 nuligestas, eutróficas, não praticantes de atividade física, provenientes da região metropolitana do Recife (PE). Os valores de PImáx e PEmáx foram obtidos, respectivamente, a partir do VR e da CPT através de um manovacuômetro digital. A comparação entre os grupos foi feita pelo teste t de Student, e a relação dos fatores grupo e idade cronológica sobre as pressões foi avaliada através de regressão linear múltipla. **Resultados:** No grupo de primigestas e nuligestas, a média de PImáx foi de, respectivamente, 88,5 ± 16,52 cmH_2O e 94,22 ± 22,63 cmH_2O (p = 0,08), enquanto a média de PEmáx foi de 99.76 ± 18,19 cmH_2O e 98,67 ± 20,78 cmH_2O (p = 0,75). Não houve correlação entre a idade gestacional e PImáx (r = −0,06; p = 0,49) ou PEmáx (r = −0,11; p = 0,22). A relação entre idade cronológica e PImáx/PEmáx não diferiu entre primigestas e nuligestas (coeficiente angular = 0,028 e 0,453, respectivamente). **Conclusões:** As pressões respiratórias de mulheres primigestas mantiveram-se estáveis durante o ciclo gestacional e não diferem significativamente dos valores das nuligestas na faixa etária de 20-29 anos.

Descritores: Gravidez; Testes de função respiratória; Força muscular.

---

* Study carried out at the Professor Fernando Figueira Institute of Comprehensive Medicine, Recife, Brazil.
Correspondence to: Andrea Lemos. Departamento de Fisioterapia, Avenida Professor Moraes Rego, 1235, Cidade Universitária, CEP 50670-901, Recife, PE, Brasil.
Tel 55 81 3328-6797. E-mail: lemosandrea@bol.com.br
Financial support: None.
Submitted: 9 August 2010. Accepted, after review: 11 January 2011.

Introduction

Since 1969, when Black & Hyatt[1] described a satisfactory, accessible method for assessing respiratory muscle strength, a number of studies have been conducted in order to establish the appropriate reference values for the many relevant parameters.[2-5] Such studies involved various populations and age brackets, including children, adolescents, adults, and the elderly. However, reports on the behavior of respiratory muscle strength during pregnancy are still scarce, and those that have been conducted have involved small samples.[6-8]

During pregnancy, the respiratory system undergoes a series of physiological changes to adapt to the new maternal and fetal oxygen demands. In the first weeks of gestation, the maternal respiratory rate does not change significantly, but there is an increase in minute volume due to greater tidal volume.[8] Changes also occur in rib cage configuration and in static lung volumes. A 4- to 5-cm elevation of the diaphragm leads to a 2-cm increase in the transverse and anteroposterior diameters, with a consequent drop in functional residual capacity (FRC) of 300-500 mL.[7-9] The decrease in FRC is a consequence of a decrease in expiratory reserve volume of 100-300 mL and a decrease in RV of 200-300 mL. However, there is no significant change in TLC, because there is an increase in inspiratory capacity (of 100-300 mL).[10]

Although volume changes, lung capacities, and anatomical changes to the rib cage during pregnancy are well documented in the literature, investigations regarding muscle strength values in pregnant women are scarce, and those that have been conducted have certain methodological limitations. In addition, there are specific clinical conditions involving the respiratory system during pregnancy, such as those related to neuromuscular diseases, in which it is necessary to monitor respiratory muscle strength during prenatal care.[11,12]

Given the need to study the behavior of respiratory muscle strength during pregnancy, the objective of the present study was to describe the MIP and MEP values obtained in a sample of primigravidae and to compare them with those found in a sample of nulligravidae.

Methods

This was a cross-sectional study in which data were collected between January of 2008 and March of 2009 at the Women's Outpatient Clinic of the Professor Fernando Figueira Institute of Comprehensive Medicine, located in the city of Recife, Brazil.

The sample, which was selected sequentially, included 120 primigravidae (5th-40th week of gestation) and 40 nulligravidae, all of whom were recruited from the metropolitan area of Recife, Brazil. The inclusion criteria were as follows: being between 20 and 29 years of age; not exercising regularly; being of normal weight; and (for those who were pregnant) being at low obstetric risk. For the primigravidae, benchmark body mass index (BMI) values were based on the BMIs considered appropriate for gestational age, in accordance with the method described by Atalah et al.,[13] whereas, for the nulligravidae, a BMI of 20-25 kg/m^2 was considered appropriate.[14] The exclusion criteria were as follows: deformities of the spine or rib cage; a history of smoking or lung disease; a cold or the flu; a neuromuscular disease; and an inability to understand or to perform the procedures.

The study design was approved by the human research ethics committee of the above-mentioned institute (protocol no. 986/2007). All study participants gave written informed consent, in accordance with Brazilian National Health Council Resolution 196/96.

In an initial assessment, personal, sociodemographic, and anthropometric data were collected for all participants. Gestational age was calculated on the basis of the date of the last period or on the basis of first trimester ultrasound when there was uncertainty regarding the date of the last period.

Measurements of MIP and MEP were obtained, always in the morning, with a systematically calibrated digital manometer with a unidirectional valve (model MVD300; G-MED®, Porto Alegre, Brazil) with a background scale of 1-480 cmH_2O. Measurements were performed with the participants sitting in a chair with a backrest, with their feet on the ground and their hips and knees at 90°, and breathing through an oval mouthpiece (2.8 × 0.7 cm) with an

intermediate nozzle with a 2-mm outlet. A nose clip was also used. With one hand, the participants held the mouthpiece firmly, pressing it against their lips, thereby preventing perioral leak during the maneuvers, supporting their cheeks with the other hand.

Before performing the maneuvers, each volunteer was given instructions and a demonstration on the use of the manometer, so that maximal respiratory pressures would be measured correctly. As a test, three maneuvers were performed prior to the first data collection.

Measurements of MIP were obtained from RV. To that end, the participants were instructed to exhale down to RV and then inhale deeply into the manometer. Measurements of MEP were obtained from TLC. To that end, the participants were instructed to inhale up to TLC and then exhale completely into the manometer.

The same verbal encouragement was given to each participant, in addition to visual feedback on the device screen, so that maximal effort was reached at the time of measurement of respiratory pressures.

For each lung volume, at least three maneuvers were performed, at 60-s intervals. Values were registered only for maneuvers that were stable for at least 1 s, in which there were no air leaks and there was a ≤ 10% variation, the highest value being selected for the final analysis.

The International Physical Activity Questionnaire-Short Form, version 8, was used in determining the level of physical activity, and the results are expressed as min/week.[15]

The values for the groups are expressed as means and standard deviations. We used Student's t-test to evaluate differences between groups and we used ANOVA to evaluate differences among groups. Pearson's correlation coefficient was used for assessing the association between respiratory pressures and gestational age. Linear regression models were adjusted to determine whether group or chronological age correlated with MIP or MEP.

The Minitab software program, version 14.0 (Minitab Inc., State College, MA, USA), was used for the statistical analysis, and a confidence level of 95% was used in all tests. Values of $p < 0.05$ were considered significant.

Results

The mean age in the primigravida and nulligravida groups was 23.34 ± 2.7 years and 24.05 ± 3.02 years, respectively, with no significant difference between the two groups.

The groups studied were homogeneous in terms of the level of physical activity and the mean MIP and MEP values, which did not differ significantly between primigravidae and nulligravidae (Table 1). There were also no significant differences among the mean MIP/MEP values for primigravidae in the three trimesters of pregnancy or between the mean MIP/MEP values for primigravidae and those obtained for nulligravidae (Table 2).

The mean gestational age in the primigravida group was 27.3 ± 8.79 weeks. In addition, gestational age was not associated with MIP ($r = -0.06$; $p = 0.49$) or MEP ($r = -0.11$; $p = 0.22$).

As can be seen in Figures 1 and 2, there were no significant variations in MIP or MEP in function of age for primigravidae or nulligravidae. Nor were there any statistically significant differences between the mean MIP/MEP values for nulligravidae and those obtained for primigravidae, regardless of age.

Discussion

Within this sample of women in the 20-29 year age bracket, the MIP and MEP values in

Table 1 - Anthropometric and cardiorespiratory values of nulligravidae and primigravidae in the 20-29 year age bracket.[a]

Variable	Nulligravidae (n = 40)	Primigravidae (n = 120)	p
Height, m	1.63 ± 0.07	1.60 ± 0.06	0.004
Weight, kg	58.9 ± 6.19	63.43 ± 6.9	< 0.01
BMI, kg/m²	22.15 ± 1.64	24.83 ± 1.91	< 0.01
LPA, min/week	878.61 ± 709.01	930.12 ± 1535.55	0.83
MIP, cmH_2O	94.22 ± 22.63	88.50 ± 16.52	0.08
MEP, cmH_2O	98.67 ± 20.78	99.76 ± 18.19	0.75

BMI: body mass index; and LPA: level of physical activity. [a]Values expressed as mean ± SD.

Table 2 - Mean maximal respiratory pressures in nulligravidae and in primigravidae in the three trimesters of pregnancy.[a]

Respiratory pressure	Primigravidae			Nulligravidae
	1st trimester (GW 5-13) (n = 12)	2nd trimester (GW 14-27) (n = 52)	3rd trimester (GW 28-40) (n = 56)	(n = 40)
MIP, cmH_2O	88.20 ± 14.39	90.40 ± 17.05	86.80 ± 16.52	94.22 ± 22.63
MEP, cmH_2O	102.50 ± 27.19	102.17± 18.6	96.94 ± 15.20	98.67 ± 20.78

GW: gestational week. [a]Values expressed as mean ± SD. Comparison of the means among the three trimesters of pregnancy (ANOVA): MIP: p = 0.509; and MEP: p = 0.285. Comparison of the means between nulligravidae and primigravidae in the three trimesters of pregnancy (ANOVA): MIP: p = 0.260; and MEP: p = 0.486.

the primigravida group were similar to those in the nulligravida group and remained so throughout the study period. These findings add to our understanding of the behavior of respiratory pressures during pregnancy, because, contrary to conventional expectations,[16] the morphological and physiological adaptations of the respiratory system imposed by pregnancy do not impair respiratory muscle strength. Although the difference between the two groups in terms of MIP (5.72 cmH_2O; 6.07%) was of borderline statistical significance, a decrease in respiratory pressure of this magnitude cannot be attributed to reduced inspiratory muscle strength.[17,18] However, it could be explained by the lower residual lung volume seen in this population.

Our results can be explained by respiratory biomechanics, because decreased chest wall compliance caused by increased abdominal pressure at the end of exhalation, due to the expansion of the uterus, reduces FRC and changes the resting position of the respiratory system.[7,19] Consequently, with the elevation of the diaphragm, its area of apposition with the rib cage increases, which increases its ability to produce tension.[6] In addition, there is diminished abdominal compliance, which favors the control of the descent of the diaphragm and the maintenance of its fibers in an advantageous length-tension relationship. Furthermore, transdiaphragmatic pressure does not change,[7,16] and studies have shown an increase in diaphragmatic excursion and a balanced contribution of intercostal and diaphragm muscles to tidal volume,[7,16,20] which facilitates the maintenance of muscle strength.

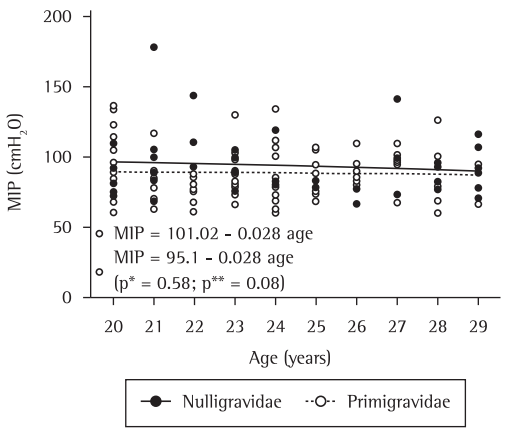

Figure 1 - Comparison of MIP values between primigravidae and nulligravidae, by age. *difference among ages within each group; **difference between the two groups at each age.

Together with all of these physiological adjustments, the maintenance of lung compliance and the decrease in airway resistance during pregnancy decrease the burden on the respiratory muscles, aiding their performance, because there is no increase in respiratory effort.[21,22] Therefore, all of these adaptations favor the muscle mechanics, maintaining the effectiveness of the inspiratory muscles, despite the progressive thoracoabdominal distortion imposed by pregnancy.

Similarly, the expiratory mechanics also seem to adapt. It might be assumed that the abdominal distension imposed by pregnancy results in a decrease in MEP, reducing expiratory strength. However, the results of the present study do not confirm that assumption. According to one group of authors,[23] the maintenance of abdominal tensile strength during pregnancy could be explained by neuromuscular function. The muscle, when submitted to prolonged stretching, reacts by changing its length through an increase in the number of sarcomeres. This process, known as myofibrillogenesis,[24] facilitates the overlap of actin and myosin

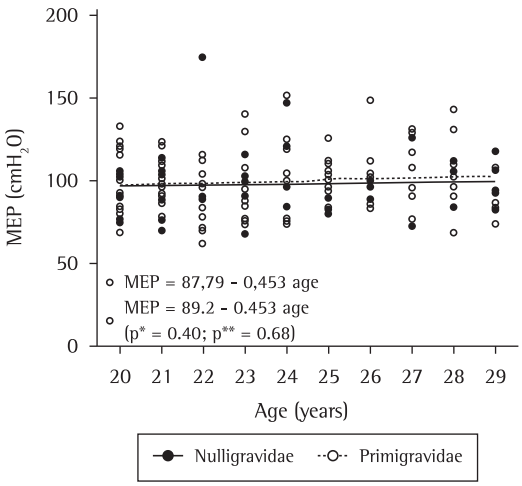

Figure 2 - Comparison of the MEP values between primigravidae and nulligravidae, by age. *difference among ages within each group; **difference between the two groups at each age.

filaments, increasing the maximum tension produced by the muscle.

In view of these facts, together with the finding that MIP and MEP remained constant throughout pregnancy, it seems that the morphological, physiological, and biomechanical adaptations occurring in the respiratory system help to minimize the progressive changes in the shape and configuration of the abdomen, diaphragm, and chest wall, thereby allowing the maintenance of respiratory muscle strength.

As expected, age had no effect on respiratory pressure values, because there was control of a ten-year age bracket for homogenizing the analysis of the results between the groups studied, excluding pregnant adolescents.

Although there were differences in height between the groups, the similarity of the respiratory pressures between them indicates that this factor did not affect the values found, which is consistent with the results of other studies in the literature, which also show that height does not affect MIP or MEP.[1-3,5]

The values found for our pregnant population were slightly different from those obtained in three other studies,[6,7,22] in which the mean MIP and MIP values were 76, 86, and 88 cmH_2O and 104, 94, and 93 cmH_2O, respectively. Similarly, one group of authors,[8] evaluating MIP and MEP in pregnant women with and without dyspnea, found mean MIP values ranging from 78.0 to 81.9 cmH_2O and mean MEP values ranging from 97.2 to 106.8 cmH_2O. The authors found no significant differences between the two groups. However, all four of those studies involved small samples (between 8 and 23 pregnant women), included primiparae and multiparae, and did not involve a group of non-pregnant women. In addition, in two of those studies,[6,22] the women were evaluated only during the third trimester of pregnancy. Pregnant women were monitored after delivery in only two of studies as well.[7,22]

When comparing the respiratory pressures found in this study with the reference values for the Brazilian female population in the same age bracket and using the same methodology as that used in the study producing those reference values,[5] we found the values to be lower than the reference values in both of the groups studied.

One study showed the mean MIP and MEP values for women in the 20-29 age bracket to be 101.6 and 114.1 cmH_2O, respectively.[5] For pregnant women, this represents a value of approximately 87% of predicted and could be interpreted as a loss of respiratory strength. However, according to the American Thoracic Society[25] and the European Respiratory Society,[26] reference values in the lower limits for function tests should be considered to be below the 5th percentile, using 80% of the predicted value being considered inappropriate.

Although the abovementioned comparison has no clinical repercussions, it raises questions regarding the standardization of the reference values found in the literature. European,[26] American,[25] and Brazilian[27] respiratory guidelines on pulmonary function warn about the generalization of reference values to the general population, due to the great interindividual variability, and encourage the development of predictive values based on socioeconomic, anthropometric, geographic, and racial differences in order to ensure their clinical applicability.

In the present study, we considered the various factors that can interfere with the measurement of respiratory pressures.[28] Measurements were obtained from maximal lung volumes, always preceded by a rapid inhalation or exhalation.[29] A 2-mm outlet[30] and a nose clip were used. The participants were always encouraged in the same way, there was previous training, and three to five technically

acceptable maneuvers were obtained in the same evaluation session. The long-term learning effect was minimized by the fact that the groups were evaluated only once. In addition, the values of primigravidae were compared with those of a population of nulligravidae with the same level of physical activity, as well as with similar social, anthropometric, and racial characteristics.

Therefore, in view of the methodological control of the procedures, we can consider that the values found are representative of the behavior of respiratory muscle strength during pregnancy in women in the 20-29 age bracket only for the population studied here. Conversely, although we found that respiratory muscle strength did not differ between primigravidae and nulligravidae in this age bracket, our data should be considered with caution, because the power of the sample was insufficient to allow any conclusions to be drawn. Therefore, on the basis of our results, we can suggest that the respiratory pressures of women aged 20-29 years remain constant during pregnancy and are similar between primigravidae and nulligravidae, although we cannot exclude the possibility that the two groups differ in terms of MIP. These findings provide elements for the understanding of respiratory muscle biomechanics in pregnant women.

References

1. Black LF, Hyatt RE. Maximal respiratory pressures: normal values and relationship to age and sex. Am Rev Respir Dis. 1969;99(5):696-702.
2. Wilson SH, Cooke NT, Edwards RH, Spiro SG. Predicted normal values for maximal respiratory pressures in Caucasian adults and children. Thorax. 1984;39(7):535-8.
3. Vincken W, Ghezzo H, Cosio MG. Maximal static respiratory pressures in adults: normal values and their relationship to determinants of respiratory function. Bull Eur Physiopathol Respir. 1987;23(5):435-9.
4. Enright PL, Kronmal RA, Manolio TA, Schenker MB, Hyatt RE. Respiratory muscle strength in the elderly. Correlates and reference values. Cardiovascular Health Study Research Group. Am J Respir Crit Care Med. 1994;149(2 Pt 1):430-8.
5. Neder JA, Andreoni 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.
6. Gilroy RJ, Mangura BT, Lavietes MH. Rib cage and abdominal volume displacements during breathing in pregnancy. Am Rev Respir Dis. 1988;137(3):668-72.
7. Contreras G, Gutiérrez M, Beroíza T, Fantín A, Oddó H, Villarroel L, et al. Ventilatory drive and respiratory muscle function in pregnancy. Am Rev Respir Dis. 1991;144(4):837-41.
8. García-Rio F, Pino JM, Gómez L, Alvarez-Sala R, Villasante C, Villamor J. Regulation of breathing and perception of dyspnea in healthy pregnant women. Chest. 1996;110(2):446-53.
9. Thomson KJ, Cohen ME. Studies in the circulation in pregnancy II. Vital capacity observations in normal pregnant women. Surg Gynecol Obstet. 1938;66:591-603.
10. Nørregaard O, Schultz P, Ostergaard A, Dahl R. Lung function and postural changes during pregnancy. Respir Med. 1989;83(6):467-70.
11. Khan ZA, Khan SA. Myotonic dystrophy and pregnancy. J Pak Med Assoc. 2009;59(10):717-9.
12. Argov Z, de Visser M. What we do not know about pregnancy in hereditary neuromuscular disorders. Neuromuscul Disord. 2009;19(10):675-9.
13. Atalah E, Castillo C, Castro R, Aldea A. Proposal of a new standard for the nutritional assessment of pregnant women [Article in Spanish]. Rev Med Chil. 1997;125(12):1429-36.
14. World Health Organization. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age. Methods and development. Geneva: World Health Organization, Department of Nutrition for Health and Development; 2006.
15. International Physical Activity Questionnaires - IPAQ [homepage on the Internet]. Huddinge: IPAQ [cited 2010 Aug 9]. Guidelines for data processing and analysis of the international physical activity questionnaire (IPAQ)-short and long forms. [Adobe Acrobat document, 15p.] Available from: http://www.ipaq.ki.se/scoring.pdf
16. Field SK, Bell SG, Cenaiko DF, Whitelaw WA. Relationship between inspiratory effort and breathlessness in pregnancy. J Appl Physiol. 1991;71(5):1897-902.
17. American Thoracic Society/European Respiratory Society. ATS/ERS Statement on respiratory muscle testing. Am J Respir Crit Care Med. 2002;166(4):518-624.
18. Hautmann H, Hefele S, Schotten K, Huber RM. Maximal inspiratory mouth pressures (PIMAX) in healthy subjects--what is the lower limit of normal? Respir Med. 2000;94(7):689-93.
19. Marx GF, Murthy PK, Orkin LR. Static compliance before and after vaginal delivery. Br J Anaesth. 1970;42(12):1100-4.
20. McGinty AP. The comparative effects of pregnancy and phrenic nerve interruption on the diaphragm and their relation to pulmonary tuberculosis. Am J Obstet Gynecol. 1938;35:237-48.
21. Gee JB, Packer BS, Millen JE, Robin ED. Pulmonary mechanics during pregnancy. J Clin Invest. 1967;46(6):945-52.
22. Jensen D, Webb KA, Davies GA, O'Donnell DE. Mechanical ventilatory constraints during incremental cycle exercise in human pregnancy: implications for respiratory sensation. J Physiol. 2008;586(Pt 19):4735-50.
23. Gilleard WL, Brown JM. Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. Phys Ther. 1996;76(7):750-62.
24. De Deyne PG. Application of passive stretch and its implications for muscle fibers. Phys Ther. 2001;81(2):819-27.

25. Lung function testing: selection of reference values and interpretative strategies. American Thoracic Society. Am Rev Respir Dis. 1991;144(5):1202-18.
26. Quanjer PH, Tammeling GJ, Cotes JE, Pedersen OF, Peslin R, Yernault JC. Lung volumes and forced ventilatory flows. Report Working Party Standardization of Lung Function Tests, European Community for Steel and Coal. Official Statement of the European Respiratory Society. Eur Respir J Suppl. 1993;16:5-40.
27. Pereira CA. Espirometria. J Pneumol. 2002;28(Suppl 3):S1-S82.
28. Souza RB. Pressões respiratórias estáticas máximas. J Pneumol. 2002;28(Suppl 3):S155-165.
29. Zakynthinos S, Vassilakopoulos T, Mavrommatis A, Roussos C, Tzelepis GE. Effects of different expiratory maneuvers on inspiratory muscle force output. Am J Respir Crit Care Med. 1999;159(3):892-5.
30. Mayos M, Giner J, Casan P, Sanchis J. Measurement of maximal static respiratory pressures at the mouth with different air leaks. Chest. 1991;100(2):364-6.

About the authors

Andrea Lemos
Professor. Department of Physical Therapy, Federal University of Pernambuco, Recife, Brazil.

Ariani Impieri Souza
Obstetrician. Professor Fernando Figueira Institute of Comprehensive Medicine, Recife, Brazil.

Armele Dornelas de Andrade
Professor. Department of Physical Therapy, Federal University of Pernambuco, Recife, Brazil.

José Natal Figueiroa
Statistician. Professor Fernando Figueira Institute of Comprehensive Medicine, Recife, Brazil.

José Eulálio Cabral-Filho
Professor. Professor Fernando Figueira Institute of Comprehensive Medicine, Recife, Brazil.