January30, 2023

(https://www.facebook.com/Medical-And-Research-Publications-103407504768536/) (https://www.linkedin.com/in/reena-s-7a72941a3)
(https://mobile.twitter.com/PublicationsMar) (https://www.instagram.com/marpublications/)

Abstract Volume: 4 Issue: 1 ISSN:

The Influence of BMI on Respiratory Muscle Pressures and Spirometric Parameters: A Portuguese Perspective

Cláudia Oliveira[1,2,3], Anabela Veiga [4,5], Miguel Guimarães[3], Cristiana Martins[3].

1. Escola Superior de Saúde do Porto- Politécnico do Porto, R. Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal
2. Unilabs Portugal, Avenida Infante D. Henrique nº129, 3700-298 São João da Madeira, Portugal
3. Hospitalar Center of Vila Nova de Gaia / Espinho EPE, Rua Conceição Fernandes 4434-502, Gaia, Portugal
4. Laboratory for Process Engineering, Environment, Biotechnology & Energy, Dep. of Chemical Engineering, Faculty of Engineering of Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal
5. Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Diogo Botelho 1327, 4169-005 Porto, Portugal

Corresponding Author: Cláudia Oliveira, Hospitalar Center of Vila Nova de Gaia / Espinho EPE, Rua Conceição Fernandes 4434-502, Gaia, Portugal

Copy Right: © 2021 Cláudia Oliveira, this is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received Date: November 27, 2021

Published date: December 01, 2021

Abstract

Background and Aim of the Study: *Obesity is currently one of the biggest social problems and can be assessed using several indicators. The Body Mass Index (BMI) is a simple method to evaluate body fatness. Thus, the effects of BMI on the respiratory system have been increasingly studied in the field of pneumology. The main objective of this work was to verify if there is an influence of BMI on the strength of the respiratory muscles and spirometric parameters.*

Material and Methods: *This study was conducted using a sample that consisted of 374 individuals. For that, the clinical processes of patients who underwent preoperative assessment were consulted and divided according to different BMI classes. The data was analyzed in an encrypted database IBM SPSS Statistics software.*

Results: *The results obtained showed that there are significant statistically differences between maximal inspiratory pressure (MIP) (p-value <0.001, p-value <0.001, p-value= 0.006, for gender, age and BMI, respectively), for maximal expiratory pressure (MEP) (p-value <0.001 for gender and p-value = 0.001 for BMI), for forced expiratory volume in one second (FEV1) (p-value =0.018 for gender), for forced expiratory volume (FEV) (p-value = 0.006 for gender, p-value = 0.005 for BMI) and FEV1/FVC relation (p-value <0.001, age). A negative correlation between BMI and MIP was evidenced. Moreover, the gender of the patient influences the variables studied since women have higher values of MIP and men of MEP.*

Conclusions*: The current study is the first to address the relationship between BMI, spirometry tests and respiratory muscle strength in Portugal.*

Keywords*: Body Mass Index, maximal inspiratory pressure, maximal expiratory pressure, spirometry, obesity.*

The Influence of BMI on Respiratory Muscle Pressures and Spirometric Parameters: A Portuguese Perspective

Introduction

Obesity is increasingly becoming one of the biggest social and cultural problems, representing an economical burden for national health systems worldwide. This chronic disease is a long-term or lifelong condition for most persons and is considered as one the most prevalent chronic metabolic diseases (1–6). In order to establish a patient's clinical treatment or to simply change their daily eating and physical exercise practices, it is important to identify this disease and evaluate its severity. The Body Mass Index (BMI) is a measure of body fat based on height and weight (1). A high BMI can be an indicator of high body fatness, even though it does not consider fat distribution in the body. BMI is a simple, fast, and inexpensive method that can be used to screen for weight categories that may lead to health problems, such as obesity (7).

Obesity can lead to multiple systemic complications, some of which result in severe impairment of organs and tissues. Therefore, people who have obesity are at increased risk for many serious diseases and health conditions. The increased deposition of fat on the chest wall causes a reduction in chest compliance and lung volume, leading to impaired respiratory mechanics and gas exchange, hence creating greater resistance in muscles and less lung compliance (4,5,8,11). In this context, the effects of obesity and BMI on the respiratory system have been increasingly studied.

Respiratory muscle strength assesses respiratory muscle performance and are often used to quantify the severity in patients with pulmonary, neuromuscular or cardiovascular disease, and can also used in rehabilitation programs and in pre- and post-operative situations (6,10–15). Moreover, it can be used as a tool to detect pulmonary dysfunction in obese individuals (1).

The respiratory muscle strength can be assessed by measuring the maximal inspiratory pressure (MIP), and the maximal expiratory pressure (MEP) (2). MIP reflects the residual volume and is the maximum negative pressure generated by a maximum inspiration and, it reflects the strength of the inspiratory muscles (diaphragm, internal intercostal muscles of the parasternal region, external intercostal and other accessory muscles) (6,8,16). MEP encompasses total lung capacity, and is generated by positive pressure, translating the strength of expiratory muscles (lateral internal intercostal muscles and abdominal muscles) (6,16).

Several studies have demonstrated an inverse relationship between the increase in BMI and the decrease in respiratory muscle pressures, due to restrictive pulmonary weakness, but also in result of the decrease in muscle strength and endurance, which translates into decreased MIP and MEP (3,6,17). In contrast, other authors argue that there is an inversion of respiratory muscle fibers in obese individuals, which leads to changes in respiratory muscle pressures. According to these authors, this occurs due to the existence of a large amount of type II muscle fibers (fast contraction) and a small amount of type I fibers (slow contraction), creating a great potential to generate muscle strength (1,4,17,18). Some studies have also found that there is a strong weakness of the peripheral muscles in people over 60 years of age or older, as respiratory muscle strength decreases with body composition and with advancing age (15,19,20).

Respiratory muscle strength is not the only method to evaluate a patient breathing capacity. Another method widely used due to its simplicity of use and quick results is spirometry. With this noninvasive and portable technique, sensitive to early change and reproducible it is possible to detect the presence or absence of lung disease and quantify lung impairment (21). Spirometry measures two key factors: expiratory forced vital capacity (FVC) measures how much air a person can exhale during a forced breath and forced expiratory volume in one second (FEV1), corresponds to tge amount of air exhaled may be measured during the first second. FEV1/FVC relation and peak expiratory flow (PEF), which is a person's maximum speed of expiration, are other parameters that can be obtained (21,22).

Thus, the aim of this work is to determine which spirometric parameters or respiratory muscle pressures have the greatest influence from BMI and identify the correlations between the considered variables.

Material and Methods

Study design

The conducted study was databased, retrospective, and cross-sectional. Inclusion criteria included all individuals without a previously diagnosed respiratory disease that had conducted a pre-operative assessment that included spirometry and respiratory muscle strength measurement. Exclusion criteria included all individuals who had a to respiratory or neuromuscular pathology, mild, moderate, or severe obstruction or obstruction of the small airways, demonstrated by spirometry and / or lack of collaboration.

The data was collected at the pulmonology service of the "Centro Hospitalar de Vila Nova de Gai/Espinho)", and the study was approved by the Ethic Committee of this hospital, out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki), approved with number 242/2020 in 23 January of 2020 and all participants gave written informed consent. In total data from 471 participants was collected, 87 of which were excluded, as shown in Figure 1.

Figure 1. Representative scheme of sample selection and analyzed variables.

Procedure

The equipment used to perform spirometry and muscle pressures were the Vitalograph spirometer and the Respiratory Pressure Meter (MicroRPM), respectively. Both techniques are performed with a nasal clip. In spirometry, a filter is placed on the spirometer so that the user can breathe into the mouthpiece. To determination of respiratory muscle strength, a Respiratory Pressure Meter was used, in witch the user blows into a mouthpiece, applying force when the valve occlusion occurs either on inspiration (MIP) or on exhalation (MEP).

When performing spirometry, three acceptable curves were obtained with at least two reproducible ones, accordingly to the reproducibility and acceptability criteria of the international recommendations of the ERS/ATS of 2019 (23,24). Respiratory muscle strength measurements were performed according to with the international recommendations of ATS/ERS of 2002, with at least 3 measurements, both from MIP and MEP. The references value for spirometry and respiratory muscle strengths are evidenced in Table1.

Table 1. Reference values for spirometry and for respiratory muscle strengths (15,19).

Statistical analysis

Age was considered as a categorical variable and was divided into 3 categories, the first up to 40 years old, the second between 41 and 64 years old and finally a last one with patients with more than 65 years.

According to the World Health Organization (WHO) there are 6 classes of BMI (26), but as in this study there is not a similar and significant number of patients in each class, only 3 classes were considered: class 1 involves all individuals who have a BMI ≤29.99 kg/m^2, Class 2 between 30-35 kg/m^2 and Class 3 with BMI values ≥35.1 kg/m^2.

The normality of the variables was assessed using the Kolmogorov-Smirnov test. Since most of the variables considered did not follow normality, non-parametric tests were used.

To correlation BMI in respiratory muscle pressures and spirometric parameters, the variables with more influence in this study (BMI, gender and age), were selected. A linear regression was used by changing the dependent variable (MIP, MEP, FEV1, FVC, FEV1/FVC relation and PEF).

The data processing summary table was performed and included the constant variables (BMI, gender and age) and dependent variable. Through the variables that present statistically significant differences, it was possible to perceive the positive or negative coefficient in this study.

To visualize the variables that had statistically significant differences, the simple Boxplot graph was used.

All statistical tests were performed using the IBM SPSS Statistics 27 software (Armonk, NY, IBM Corp.), considering a significance level of 0.05.

Results

Regarding the data used in this study, collected from the different individuals, a statistical description of the parameters for male and female are described in table 2 and 3, respectively.

Table 2. Statistical parameters for the variables considered in male individuals.
Table 3. Statistical parameters for the variables considered in female individuals.

In the statistical analysis, the MIP, MEP (gender, BMI), FEV1 (Age), FVC (gender, BMI) and FEV1/FVC relation (Age) variables showed statistically significant differences, with p values <0.05. In the remaining variables, primarily in MEP, there were no statistically significant differences, with p values> 0.05.

As for the spirometric data, it was verified that there is a decrease in the FVC values with the increase in the BMI. The age variation is positively presented in the FEV1 values, that is, there is no decrease in the values, contrary to what happens in the FEV1/FVC relation, since there is a decrease in the values with increasing age. These results are described in Table 4.

Table 4. Variables characterization. All variables are described by the p-value and by the non-standardized coefficient, obtained through linear regression test.

Figure 2A shows the boxplot between MIP and gender since it has significant statistically differences. The boxplot represents the central trend (i.e., the median of age) and dispersion (observations between the P25-P75), being data from extreme values represented by points. Male individuals are represented by the number 1, while female by number 2.

In is possible to verify that the MIP values are higher in females, as shown in the nom-standardized coefficient value, shown in table 3.

Figure 2B shows the boxplot between MIP and Age. There is a difference between the P25-P75 justified by the variability of the data. Class 1 is represented with ages up 40 years old, class 2 with ages between 41-64 years old and Class 3 ages above 65 years old. It is shown that there is greater variability between the median and the P75 ages up to 40 years. It is also noticeable that in fact, in comparison with younger ages, class 2 presents lower MIP values, but in contrast to individuals with higher ages have the highest MIP values.

Regarding Figure 2C, the boxplot between the MIP and BMI, shows that there is no great variability between the percentiles in the different classes. Class 1 represents values bellow ≤ 29.99 m^2/Kg, Class 2 with BMI values between 30-35 m^2/Kg and Class 3 with BMI values ≥ 35.1 m^2/Kg. It is possible to verify that according to the increase in the BMI, the MIP values decrease, mainly in Class 2, as shown by the linear regression test, with a negative non-standardized coefficient.

Figure 2. Boxplots representing the variation between (A) MIP and gender, (B) MIP and Age and (C) MIP and BMI.

Figure 3A. shows the correlation between MEP and gender on Boxplot. It appears that there are lower values of MEP in the female individuals, that is, the male gender has much higher values of MEP than female gender.

Figure 3. Boxplots representing the variation between (A) MEP and gender, (B) MEP and Age and (C) MEP and BMI.

Figure 3B shows that there is a decrease in MEP values in older individuals, that is, in individuals older than 65 years old, compared to the age group between 41-64 years old. It appears that there is a great variability in the values of Class 1 and Class 3.

Finally, in figure 3C the boxplot that relates BMI and MEP, it is possible to verify that there is no correlation with the increase in BMI and MEP values, as demonstrated by the positive value of the non-standardized coefficient, obtained by the regression linear. It is also observed that individuals with a BMI between 30-35 m^2/kg have higher values of MEP.

Discussion

In the present work, significant statistically differences in MIP, MEP (gender, BMI), FEV1 (Age), FVC (gender, BMI) and FEV1/FVC relation (Age) were evidenced. It was found that females have higher MIP values than males, in contrast, males have higher MEP values. Differences with increasing age in the values of respiratory muscle pressures were not evidenced. On the other hand, there was a slight decrease in MIP values, with an increase in BMI. Regarding the spirometric values, it was found that there is a decrease in the FVC values with an increase in the BMI.

In the literature it is well established that obesity has detrimental effects on general health and respiratory functions (2,4). In fact, the lung function is influenced by the progressive increase in BMI, being these effects more evident when BMI> 50.9 kg/m² (8). The inexistence of a correlation between BMI and respiratory muscle strengths, can be explained according to Chlif et al.,(13) that stated that patients with obesity are faced with muscle overload, especially in the inspiratory muscles. Thus, changes in thoracic–abdominal configuration also alter the fiber length and the pressure generated (independently of lung volume changes) (13).

The results from this articles are similar to those presented by Simão et al., (23) where the respiratory muscle strength was markedly reduced in elderly women aged between 60 and 89 years, especially in MEP, with a correlation between maximal respiratory pressures with age and anthropometric characteristics. Furthermore, Carpenter MA, et al., (24) reported that the relation between BMI and MIP was not linear due to different between genders, and that the peak MIP was observed at BMI 30 in men and BMI 37 in women.

Other studies such as the one conducted by Magnani et al., (17) affirmed that the maximum respiratory pressures in obese individuals are generally normal, except when they develop hypoventilation-obesity syndrome, where respiratory requirements are hindered. In addition, neck fat on the appears to hamper the ability to mobilize respiratory flow compared to general adiposity (17).

On the other hand, studies such as the ones conducted by Jácome Gonçalves et al., (17) e Costa et al., (5) show a positive correlation between obesity and MIP and MEP that can be explained by the theory that an inversion of respiratory muscle fibers occurs and leads to changes in respiratory muscle strengths with a large amount of muscle fibers of type II and a small amount of type I fibers in obese individuals (5,17,20). This means that obese people need a higher amount of oxygen, causing hyperventilation, increasing the respiratory movement of the rib cage, by means of rapid and shallow breaths, as D'Ávila Melo et al., (8) confirmed, thus developing in greater extend respiratory muscles (8,11).

Pouwels et al.,(2) and Tenório et al.,(3) observed that after bariatric surgery, even though respiratory muscle pressure values are normal, there is a decrease in respiratory muscle strength when weight loss increases, which is due to the overload decrease. On the other hand, there is a greater elasticity in the respiratory muscles (4). This relationship with surgery may explain the non-decrease in respiratory muscle pressures in obese patients. After surgery, these authors argue that there is a significant improvement in MIP and FEV1 (2,3).

In this study, it can be concluded that there is a negative correlation between age and MIP, in class 2. It should be noted that this correlation can be influenced by the BMI variable, but according to Sclauser Pessoa et al., (15) and Costes et al.,(20) MIP begins to decrease over the age group of 40 to 60 years and continues to decrease progressively with age. For the same age group, men tend to have higher MIP than women, since they have more muscle mass. Assis Navarro et al.,(19) confirmed that there was a significant difference between individuals aged 70-79 years and those aged 50-59 years (19). The primary mechanism for this reduction, according to the authors, was sarcopenia associated with the aging process, in which respiratory muscle strength decreases approximately 8-10% per decade from the age of 40 (25).

Prem et al.,(25), and Pessoa et al.,(26), identified several factors that can affect the decline in respiratory muscle strength as changes that can occur in the skeletal muscle itself (involving calcification and hardening of the rib cage joints), the elastic recoil of the lungs and chest wall and the increase in residual volume (25,26).

In this study, it was possible to verify that there are no statistically significant differences in the FEV1/FVC relation and PEF Index, which is in disaccordance with Jalai et al.,(27), who says that there is no correlation between BMI and respiratory muscle pressures, but there is a relationship with spirometric parameters (27). This phenomenon is also explained by Magnani et al.,(1), that states that patients with morbid obesity have an increase in metabolic requirements due to fat deposition, which results in a restrictive lung function disorder, thus causing a reduction in chest compliance and lung volumes, especially in FVC, FEV1 and the FEV1/FVC relation, distorting the balance in the interaction between lung, wall and diaphragm, leading to impairment in mechanics (1,2).

However, according to what was confirmed by this study, in the study by Pouwels et al.,(4) and Tenório et al.,(3), there is a decrease in respiratory muscle pressures with an increase in BMI, especially in MIP, since encompasses a greater number of muscles (3,4).

Although this is the first Portuguese study to investigate the influence of several respiratory parameters on BMI, there are limitations that must be considered. The fact that the present research paper is based on a small sample between 16 and 49 years old) made it difficult to compare spirometric parameters and respiratory muscle strength in the same class of BMI. As future perspectives it would be interesting to conduct a study in which it could be possible to have a sample with a larger number of young individuals and adults, thus allowing a more reliable and accurate assessment of the data.

Future work includes to determine if there are significant differences in respiratory muscle strength in obese individuals (Class 5 BMI) with COPD compared to normal individuals (Class 1 BMI) with COPD. Therefore, there is still a lot to be investigated in the current field.

Conclusion

Since there are several factors that influence the strength of respiratory muscles, the conducted study performs an analysis on the variables that correlate to BMI. The results obtained showed that there are significant statistically differences between maximal inspiratory pressure (MIP), for maximal expiratory pressure (MEP), for forced expiratory volume in one second (FEV1), for forced expiratory volume (FEV) and FEV1/FVC relation. A negative correlation between BMI and MIP was evidenced. Moreover, the gender of the patient influences the variables studied since women have higher values of MIP and men of MEP. It was found that there is negative correlation between BMI and MIP. Regarding the spirometric data, the data suggests that in addition to FVC values, there are no other significant influences.

Reference

1. Magnani KL, Cataneo AJM. Respiratory muscle strength in obese individuals and influence of upper-body fat distribution. Sao Paulo Med J [Internet]. 2007 Jul;125(4):215–9. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516318020070004000004&lng=en&tlng=en (1.%20Magnani%20KL,%20Cataneo%20AJM.%20Respiratory%20muscle%20strength%20in%20obese%20individuals%20and%20influence%20of%
body%20fat%20distribution.%20Sao%20Paulo%20Med%20J%20%5bInternet%5d.%202007%20Jul;125(4):215–9.%20Available%20from:%20http:/www.scielo.br/scielo.php?script=sci_arttext&pid=S1516318020070004000004&lng=en&tlng=en)

2. Pouwels S, Buise MP, Smeenk FWJM, Teijink JAW, Nienhuijs SW. Comparative analysis of respiratory muscle strength before and after bariatric surgery using 5 different predictive equations. J Clin Anesth [Internet]. 2016 Aug;32:172–80. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0952818016300101 (file:///D:/Proofs/3.%20October/PY/2.%20Pouwels%20S,%20Buise%20MP,%20Smeenk%20FWJM,%20Teijink%20JAW,%20Nienhuijs%20SW.%20C
80.%20Available%20from:%20http:/linkinghub.elsevier.com/retrieve/pii/S0952818016300101)

3. Tenório LHS, Santos AC, Câmara Neto JB, Amaral FJ, Passos VMM, Lima AMJ, et al. The influence of inspiratory muscle training on diaphragmatic mobility, pulmonary function and maximum respiratory pressures in morbidly obese individuals: a pilot study. Disabil Rehabil [Internet]. 2013 Oct 7;35(22):1915–20. Available from: http://www.tandfonline.com/doi/full/10.3109/09638288.2013.769635 (file:///D:/Proofs/3.%20October/PY/3.%20Tenório%20LHS,%20Santos%20AC,%20Câmara%20Neto%20JB,%20Amaral%20FJ,%20Passos%20VMM
20.%20Available%20from:%20http:/www.tandfonline.com/doi/full/10.3109/09638288.2013.769635)

4. Pouwels S, Kools-Aarts M, Said M, Teijink JAW, Smeenk FWJM, Nienhuijs SW. Effects of bariatric surgery on inspiratory muscle strength. Springerplus [Internet]. 2015 Dec 7;4(1):322. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26180742%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4493261 (file:///D:/Proofs/3.%20October/PY/4.%20Pouwels%20S,%20Kools-Aarts%20M,%20Said%20M,%20Teijink%20JAW,%20Smeenk%20FWJM,%20Nienhuijs%20SW.%20Effects%20of%20bariatric%20surgery%20on%2
artid=PMC4493261)

5. Costa TR, Lima TP, Gontijo PL, Carvalho HA, Cardoso FP, Faria OP, et al. Correlation of respiratory muscle strength with anthropometric variables of normal-weight and obese women. Rev Assoc Med Bras. 2010;56(4):403–8. (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3616895&tool=pmcentrez&rendertype=abstract)

6. Sachs MC, Enright PL, Hinckley Stukovsky KD, Jiang R, Barr RG. Performance of maximum inspiratory pressure tests and maximum inspiratory pressure reference equations for 4 race/ethnic groups. Respir Care [Internet]. 2009;54(10):1321–8. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3616895&tool=pmcentrez&rendertype=abstract (file:///D:/Proofs/3.%20October/PY/6.%20Sachs%20MC,%20Enright%20PL,%20Hinckley%20Stukovsky%20KD,%20Jiang%20R,%20Barr%20RG.%
8.%20Available%20from:%20http:/www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3616895&tool=pmcentrez&rendertype=abstract)

7. Adela Hruby, PhD M, Frank B. Hu, MD, PhD M. The Epidemiology of Obesity: A Big Picture. Pharmacoeconomics. 2015;33(7):673–89. (https://www.google.com/search?q=The+Epidemiology+of+Obesity%3A+A+Big+Picture.+&rlz=1C1ONGR_enIN971IN971&sxsrf=AOaemvJGwT1a4g300RR_95o7RrZA64z5Ew%3A16
7Lf0AhUFjuYKHeQ4B3sQ4dUDCA4&oq=The+Epidemiology+of+Obesity%3A+A+Big+Picture.+&gs_lcp=Cgdnd3Mtd2l6EAwyBQgAEIAEMgYIABAWEB4
wiz)

8. D'Ávila Melo SM, de Melo VA, de Menezes Filho RS, Santos FA. Effects of progressive increase in body weight on lung function in six groups of body mass index. Rev da Assoc Médica Bras (English Ed [Internet]. 2011 Sep;57(5):499–505. Available from: http://linkinghub.elsevier.com/retrieve/pii/S2255482311701035 (file:///D:/Proofs/3.%20October/PY/8.%20D'Ávila%20Melo%20SM,%20de%20Melo%20VA,%20de%20Menezes%20Filho%20RS,%20Santos%20FA
505.%20Available%20from:%20http:/linkinghub.elsevier.com/retrieve/pii/S2255482311701035)

9. Gudmundsson G, Cerveny M, Shasby DM. Spirometric values in obese individuals: Effects of body position. Am J Respir Crit Care Med. 1997;156(3 I):998–9. (https://www.google.com/search?q=Spirometric+values+in+obese+individuals%3A+Effects+of+body+position&rlz=1C1ONGR_enIN971IN971&sxsrf=AOaemvLNXmbTcCLYCELe1LK-WX0f9cbOHg%3A1637992195279&ei=A8ehYdDREJziz7sPvLCHwAo&ved=0ahUKEwiQ38a37Lf0AhUc8XMBHTzYAagQ4dUDCA4&oq=Spirometric+value
wiz)

10. Sgariboldi D, Pazzianotto-Forti EM. Predictive Equations for Maximum Respiratory Pressures of Women According to Body Mass. Respir Care [Internet]. 2016 Apr 1;61(4):468–74. Available from: http://rc.rcjournal.com/cgi/doi/10.4187/respcare.04204 (file:///D:/Proofs/3.%20October/PY/10.%20Sgariboldi%20D,%20Pazzianotto-Forti%20EM.%20Predictive%20Equations%20for%20Maximum%20Respiratory%20Pressures%20of%20Women%20According%20to%20Body%20I 74.%20Available%20from:%20http:/rc.rcjournal.com/cgi/doi/10.4187/respcare.04204)

11. Mellies U, Stehling F, Dohna-Schwake C. Normal values for inspiratory muscle function in children. Physiol Meas [Internet]. 2014 Oct 1;35(10):1975–81. Available from: http://stacks.iop.org/0967-3334/35/i=10/a=1975?key=crossref.e386179e2dd7bbc4146d2e3d5c1b453c (file:///D:/Proofs/3.%20October/PY/11.%20Mellies%20U,%20Stehling%20F,%20Dohna-Schwake%20C.%20Normal%20values%20for%20inspiratory%20muscle%20function%20in%20children.%20Physiol%20Meas%20%5bInternet%5c 81.%20Available%20from:%20http:/stacks.iop.org/0967-3334/35/i=10/a=1975?key=crossref.e386179e2dd7bbc4146d2e3d5c1b453c)

12. Carla H, Daltro C, Fontes FHDO, Santos-jesus R. Comparison among parameters of maximal respiratory pressures in healthy subjects. J Bras Pneumol. 2012;50(1):605–13. (https://www.google.com/search?q=Comparison+among+parameters+of+maximal+respiratory+pressures+in+healthy+subjects.&rlz=1C1ONGR_enIN971IN971&sxsrf=AOaemvIYaH 3B3LUPxrKA4Aw&ved=0ahUKEwjsq66w7Lf0AhXtILcAHUYZAMwQ4dUDCA4&oq=Comparison+among+parameters+of+maximal+respiratory+pressur wiz)

13. Chlif M, Keochkerian D, Feki Y, Vaidie A, Choquet D, Ahmaidi S. Inspiratory muscle activity during incremental exercise in obese men. Int J Obes [Internet]. 2007 Sep 26;31(9):1456–63. Available from: http://www.nature.com/articles/0803546 (file:///D:/Proofs/3.%20October/PY/13.%20Chlif%20M,%20Keochkerian%20D,%20Feki%20Y,%20Vaidie%20A,%20Choquet%20D,%20Ahmaidi%2 63.%20Available%20from:%20http:/www.nature.com/articles/0803546)

14. Arena R, Cahalin LP. Evaluation of Cardiorespiratory Fitness and Respiratory Muscle Function in the Obese Population. Prog Cardiovasc Dis [Internet]. 2014 Jan;56(4):457–64. Available from: http://dx.doi.org/10.1016/j.pcad.2013.08.001 (file:///D:/Proofs/3.%20October/PY/14.%20Arena%20R,%20Cahalin%20LP.%20Evaluation%20of%20Cardiorespiratory%20Fitness%20and%20Res 64.%20Available%20from:%20http:/dx.doi.org/10.1016/j.pcad.2013.08.001)

15. Sclauser Pessoa IMB, Parreira VF, Fregonezi GAF, Sheel AW, Chung F, Reid WD. Reference values for maximal inspiratory pressure: A systematic review. Can Respir J. 2014;21(1):43–50. (https://www.google.com/search?q=Reference+values+for+maximal+inspiratory+pressure%3A+A+systematic+review&rlz=1C1ONGR_enIN971IN971&sxsrf=AOaemvKtILHp1DWiIM 7yAU&ved=0ahUKEwj3zMio7Lf0AhUeIbcAHdDfDlkQ4dUDCA4&oq=Reference+values+for+maximal+inspiratory+pressure%3A+A+systematic+revie wiz)

16. Ro HJ, Kim D-K, Lee SY, Seo KM, Kang SH, Suh HC. Relationship Between Respiratory Muscle Strength and Conventional Sarcopenic Indices in Young Adults: A Preliminary Study. Ann Rehabil Med [Internet]. 2015;39(6):880. Available from: https://synapse.koreamed.org/DOIx.php?id=10.5535/arm.2015.39.6.880 (file:///D:/Proofs/3.%20October/PY/16.%20Ro%20HJ,%20Kim%20D-K,%20Lee%20SY,%20Seo%20KM,%20Kang%20SH,%20Suh%20HC.%20Relationship%20Between%20Respiratory%20Muscle%20Strength%20anc id=10.5535\arm.2015.39.6.880)

17. Jácome Gonçalves M, do Lago STS, de Paiva Godoy E, de Freitas Fregonezi GA, Sousa Bruno S. Influence of Neck Circumference on Respiratory Endurance and Muscle Strength in the Morbidly Obese. Obes Surg [Internet]. 2011 Aug 3;21(8):1250–6. Available from: http://link.springer.com/10.1007/s11695-010-0077-3 (file:///D:/Proofs/3.%20October/PY/17.%20Jácome%20Gonçalves%20M,%20do%20Lago%20STS,%20de%20Paiva%20Godoy%20E,%20de%20Fr 6.%20Available%20from:%20http:/link.springer.com/10.1007/s11695-010-0077-3)

18. Wang S, Sun X, Hsia TC, Lin X, Li M. The effects of body mass index on spirometry tests among adults in Xi'an, China. Med (United States). 2017;96(15):13–6. (https://www.google.com/search?q=The+effects+of+body+mass+index+on+spirometry+tests+among+adults+in+Xi%E2%80%99an&rlz=1C1ONGR_enIN971IN971&sxsrf=AOaem OqPeA&ved=0ahUKEwjS0Kmd7Lf0AhW9ILcAHXj1Aw8Q4dUDCA4&oq=The+effects+of+body+mass+index+on+spirometry+tests+among+adults+ir wiz)

19. Brandão Assis Navarro MDL, Bennemann RM. (Artigo 4 publicado v.28 n.2) Avaliação do estado nutricional de idosos residentes em uma instituição asilar da cidade de Marialva, Estado do Paraná. Acta Sci Heal Sci [Internet]. 2006 Mar 13;28(2):117–20. Available from: http://periodicos.uem.br/ojs/index.php/ActaSciHealthSci/article/view/1066 (file:///D:/Proofs/3.%20October/PY/19.%20Brandão%20Assis%20Navarro%20MDL,%20Bennemann%20RM.%20(Artigo%204%20publicado%20v. 20.%20Available%20from:%20http:/periodicos.uem.br/ojs/index.php/ActaSciHealthSci/article/view/1066)

20. Costes F, Celle S, Garet M, Kossovsky M, Roche F, Barthélémy JC. Identification and comparison of the predictors of maximal inspiratory force and handgrip in a healthy elderly population. The proof study. Clin Nutr [Internet]. 2016 Aug;35(4):963–7. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0261561415001958 (file:///D:/Proofs/3.%20October/PY/20.%20Costes%20F,%20Celle%20S,%20Garet%20M,%20Kossovsky%20M,%20Roche%20F,%20Barthélémy% 7.%20Available%20from:%20http:/linkinghub.elsevier.com/retrieve/pii/S0261561415001958)

21. Moore VC. Spirometry: step by step. Breathe [Internet]. 2012 Mar 1;8(3):232–40. Available from: http://breathe.ersjournals.com/lookup/doi/10.1183/20734735.0021711 (file:///D:/Proofs/3.%20October/PY/21.%20Moore%20VC.%20Spirometry:%20step%20by%20step.%20Breathe%20%5bInternet%5d.%202012% 40.%20Available%20from:%20http:/breathe.ersjournals.com/lookup/doi/10.1183/20734735.0021711)

22. Al Ghobain M. The effect of obesity on spirometry tests among healthy non-smoking adults. BMC Pulm Med. 2012;12. (file:///D:/Proofs/3.%20October/PY/The%20effect%20of%20obesity%20on%20spirometry%20tests%20among%20healthy%20non-smoking%20adults)

23. Simões RP, Castello V, Auad MA, Dionísio J, Mazzonetto M. Prevalence of reduced respiratory muscle strength in institutionalized elderly people Prevalência de redução da força muscular respiratória em idosas institucionalizadas. Sao Paulo Med J. 2009;127(2):78–83. (https://www.google.com/search?q=Prevalence+of+reduced+respiratory+muscle+strength+in+institutionalized+elderly+people+Preval%C3%AAncia+de+redu%C3%A7%C3%A3o+
QwPLtw%3A1637992118780&ei=tsahYe2BL5G88QPA3LIg&ved=0ahUKEwjttImT7Lf0AhURXnwKHUCuDAQQ4dUDCA4&uact=5&oq=Prevalence+of+re
wiz)

24. Carpenter MA, Tockman MS, Hutchinson RG, Davis CE, Heiss G. Demographic and anthropometric correlates of maximum inspiratory pressure: The atherosclerosis risk in communities study. Am J Respir Crit Care Med. 1999;159(2):415–22. (https://www.google.com/search?q=Demographic+and+anthropometric+correlates+of+maximum+inspiratory+pressure%3A+The+atherosclerosis+risk+in+communities+study&rlz
8)

25. Prem V, Gopalakrishna A, Vaishali K, Aaron P. Normative values for maximal respiratory pressures in an Indian Mangalore population: A cross-sectional pilot study. Lung India [Internet]. 2011;28(4):247. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3213709&tool=pmcentrez&rendertype=abstract
(file:///D:/Proofs/3.%20October/PY/25.%20Prem%20V,%20Gopalakrishna%20A,%20Vaishali%20K,%20Aaron%20P.%20Normative%20values%20
sectional%20pilot%20study.%20Lung%20India%20%5bInternet%5d.%202011;28(4):247.%20Available%20from:%20http:/www.pubmedcentral.r
artid=3213709&tool=pmcentrez&rendertype=abstract)

26. Pessoa IMBS, Houri Neto M, Montemezzo D, Silva LAM, Andrade AD de, Parreira VF. Predictive equations for respiratory muscle strength according to international and Brazilian guidelines. Brazilian J Phys Ther [Internet]. 2014 Oct;18(5):410–8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-35552014000500410&lng=en&nrm=iso&tlng=en
(file:///D:/Proofs/3.%20October/PY/26.%20%20Pessoa%20IMBS,%20Houri%20Neto%20M,%20Montemezzo%20D,%20Silva%20LAM,%20Andrade
8.%20Available%20from:%20http:/www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-35552014000500410&lng=en&nrm=iso&tlng=en)

27. Jalai R. The Assessment of Maximal Respiratory Mouth Pressures In Adults. Ethn Racial Stud [Internet]. 2004 Nov;27(6):1006–14. Available from: http://www.tandfonline.com/doi/abs/10.1080/0141987042000290328
(file:///D:/Proofs/3.%20October/PY/27.%20%20Jalai%20R.%20The%20Assessment%20of%20Maximal%20Respiratory%20Mouth%20Pressures%
14.%20Available%20from:%20http:/www.tandfonline.com/doi/abs/10.1080/0141987042000290328)

26. WHO/Europe (World Health Organization) (2021). Body mass index- BMI https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi# [accessed 18 January 2021]. (file:///D:/Proofs/3.%20October/PY/26.%20WHO/Europe%20(World%20Health%20Organization)%20(2021).%20Body%20mass%20index-%20BMI%20https:/www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi%23%20%20%5baccessed%2018%20January%202021%5d)

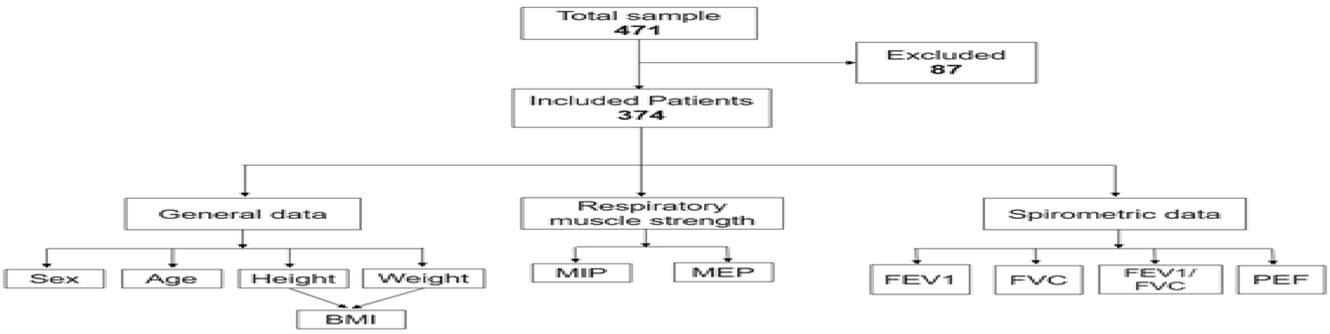

Figure 1

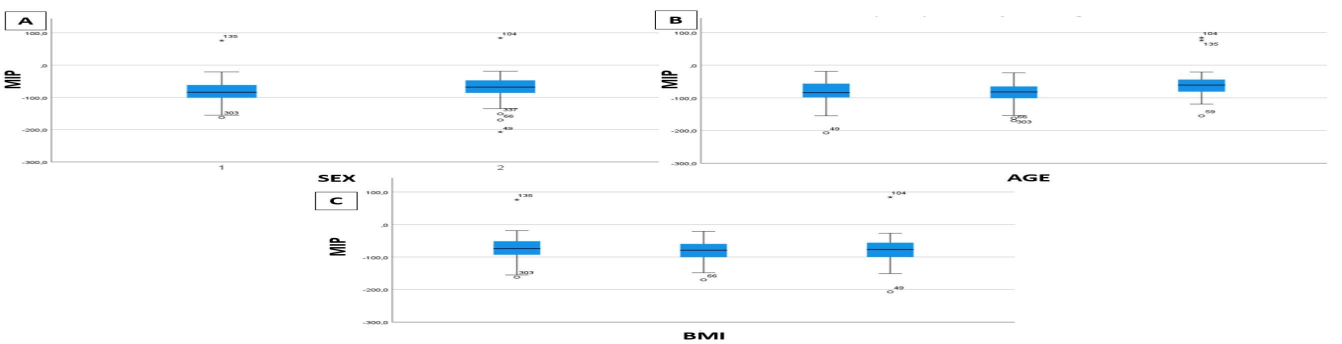

Figure 2

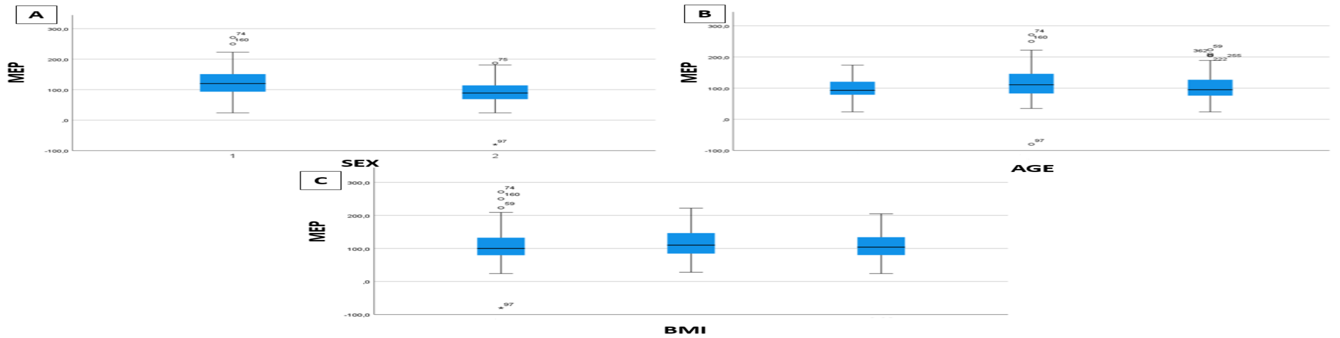

Figure 3

Respiratory parameters	Normal Value
FEV1	>80%,
FEV1/FVC relation	>70%,
Forced Vital Capacity (FVC)	>80%,
Peak Expiratory Flow (PEF)	>80 %
MIP	Women >20 cmH2O/ Men >44 cmH2O
MEP	Women >60 cmH2O/ Men >80 cmH2O

Table 1. Reference values for spirometry and for respiratory muscle strengths (15,19).

Figure 4

Statistics / Variable	Maximum	Minimum	Median	Standard deviation	Mean
Age	92	16.00	58.95	16.02	58.95
Weight [kg]	138	49.00	79.07	16.23	79.07
Height [cm]	184	132.00	167.87	7.02	167.87
BMI	48	17.40	27.91	5.15	27.91
MIP	76	-162.00	-82.94	30.48	-82.94
MEP	271	24.00	123.09	42.74	123.09
FEV_1	136	38.20	98.24	15.21	98.24
FVC	147	61.00	104.84	18.45	104.84
FEV1/FVC Ratio	108.1	31.16	80.59	8.21	80.59
PEF	164	73.40	104.63	17.97	104.63

Table 2. Statistical parameters for the variables considered in male individuals.

Figure 5

Statistics / Variable	Maximum	Minimum	Median	Standard deviation	Mean
Age	81	16.0	53.93	16.18	53.93
Weight [kg]	151	38.0	76.85	19.99	76.85
Height [cm]	180	134.0	156.44	7.16	156.44
BMI	61.3	17.0	31.51	7.80	31.51
PIM	84	-207.0	-68.99	31.45	-68.99
PEM	187	-80.0	91.93	36.46	91.93
FEV_1	158.9	70.0	99.92	15.50	99.92
FVC	177.8	70.0	101.70	16.70	101.70
FEV1/FVC Ratio	108	66.57.0	82.79	7.79	82.79
PEF	1008	54.3	108.16	71.27	108.16

Table 3. Statistical parameters for the variables considered in female individuals.

Figure 6

Dependent Variable	Constant Variable	p-value	Unstandardized Coefficient B
MIP	Gender	<0.001	19.332
	Age	<0.001	0.524
	BMI	0.006	-0.655
MEP	Gender	<0.001	-35.564
	Age	0.550	-0.076
	BMI	0.001	1.019
FEV1	Gender	0.095	2.780
	Age	0.018	0.117
	BMI	0.196	-0.157
FVC	Gender	0.006	4.714
	Age	0.052	0.099
	BMI	0.005	-0.352
FVC1/FVC relation	Gender	0.071	1.550
	Age	<0.001	-0.119
	BMI	0.212	0.078
PEF	Gender	0.876	0.853
	Age	0.466	-0.118
	BMI	0.329	0.388

Table 4. Variables characterization. All variables are described by the p-value and by the non-standardized coefficient, obtained through linear regression test.

Figure 7

Publishing

Our vision: Medical and Research Publications brought into the world with a dream of elevating your research to the broadest network and giving high visibility and exposure to your article. We likewise guarantee your research is easy to find, m..... Read More (https://medicalandresearch.com/aboutus)

(https://www.facebook.com/Medical-And-Research-Publications-103407504768536/)
(https://www.instagram.com/marpublications/) (https://mobile.twitter.com/PublicationsMar)
(https://www.linkedin.com/in/reena-s-7a72941a3)

Quick Links

Home (https://medicalandresearch.com/home)

About (https://medicalandresearch.com/aboutus)

Books (https://medicalandresearch.com/books)

Journals (https://medicalandresearch.com/journals)

Article Guide (https://medicalandresearch.com/articleguide)

Submit Manuscript (https://medicalandresearch.com/submitscript)

Latest Journals

Journal of MAR Medicine (https://medicalandresearch.com/journals/view/Journal-of-MAR-Medicine)

Journal of MAR Clinical Nephrology (https://medicalandresearch.com/journals/view/Journal-of-MAR-Clinical-Nephrology)

Journal of MAR Pathology (https://medicalandresearch.com/journals/view/Journal-of-MAR-Pathology)

Journal of MAR Anaesthesia and Pain Management (https://medicalandresearch.com/journals/view/Journal-of-MAR-Anaesthesia-and-Pain-Management)

Journal of Plastic and Reconstructive Surgery (https://medicalandresearch.com/journals/view/Journal-of-Plastic-and-Reconstructive-Surgery)

Contact Us

Info@medicalandresearch.com

Open Access by Medicalandresearch is licensed under a Creative Commons Attribution 4.0 International License.
(https://creativecommons.org/licenses/by/4.0/) Based on a work at www.medicalandresearch.com (http://medicalandresearch.com)
Copyright © 2020 Medical and Research Publications (http://medicalandresearch.com/) - All Rights reserved