International Research Journal of Multidisciplinary Scope (IRJMS), 2025; 6(1):52-57 IRJMS

Original Article | ISSN (O): 2582-631X DOI: 10.47857/irjms.2025.v06i01.02268

Identifying Respiratory Muscle Strength in Middle Aged Males and Females Based on Reference Equation

Tvisha K Patel[1, 2]*, Arvind Kumar[1], Zarana K Khamar[1, 2]

[1]Venus Institute of Physiotherapy, Gandhinagar, Gujarat, India, [2]Arush Phisiotherapy college, Shahibaug, Ahmedabad, Gujarat, India.
*Corresponding Author's Email: tvishapatel90@gmail.com

Abstract

Respiratory muscle strength is an essential part of respiratory system evaluation as the process of ventilation eventually depends on the muscles of respiration. Aging reduces the muscle mass commonly referred to as 'sarcopenia'. Thus, the middle-aged population goes under a sequential change of thoracic cages that affects the respiratory system. There are various tools available for assessment of the strength of these respiratory muscles. However, the feasibility of applying these tools is limited by their availability in various clinical settings, which poses a significant drawback when assessing their effectiveness. The reference equations on the other hand which address this issue are available to assess the respiratory muscle strength (RMS) using the maximal mouth pressures as maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP). The MIP and MEP are calculated on the basis of individual's age, height and weight. The present study thus applied the available equation to assess the RMS which included 200 volunteers (100 males and 100 female) with mean age was of 56.67± 6.89 and 58.45± 6.85 for males and females with the average height was of 167.18 ± 3.99 and 159.3 ± 2.74 with the weight of 69.14 ± 3.37 and 60.30 ± 4.08 respectively. The BMI of the study cohort was 24.26±0.70 kg/m^2. The mean MIP for males is 93.63 ± 4.84 and mean MEP is 84.84 ± 4.78 while in females the mean MIP was 69.84 ± 2.85 and mean MEP was 63.46 ± 2.86. The equations can further be utilized for identifying individual's cut off respiratory pressure for evaluating respiratory muscle weakness. It can significantly be of much importance while diagnosing neurologically affected patients for their RMS as it gives an individual's limit for inspiratory as well as expiratory muscle strength.

Keywords: Equation, Maximal Inspiratory Pressure, Maximal Expiratory Pressure, Middle-Aged Males and Females, Respiratory Muscle Strength.

Introduction

Respiratory muscle strength remains an essential part of respiratory system evaluation as the process of ventilation fundamentally relies on the muscles of respiration. When the respiratory muscles become weak the process of ventilation is adversely affected. This weakness of muscles can be multifactorial where the leading cause is aging. Ageing leads to decrease in the muscle mass which is commonly termed as 'sarcopenia' (1). Particularly when this occurs for the muscles of respiratory system, it is known as 'respiratory sarcopenia'. This condition can lead to a cascade of events. Such as increased work of breathing followed by difficulty in breathing and can progress to respiratory failure (2). This highlights the importance of the evaluation of respiratory muscle strength which is often overlooked compared to any other muscles. The focus while evaluating the respiratory system is always on the functions rather than the strength of the muscles. However, in particular disorders like COPD, MND'S, other neurological and respiratory diseases diagnosing the reduced functional capacity of the lungs is essential, but identifying the underlying cause is also equally important. This could stem from muscular weakness or abnormalities in the thoracic cage, both of which can significantly impact respiratory function. (3-5). The evaluation of respiratory system includes variety of invasive and some non-invasive tests which includes pulmonary functions: FEV1, Peak Flow Rates, Voluntary Cough Ability, Maximum inspiratory pressure, maximum expiratory pressures, Sniff pressures, Trans diaphragmatic pressures, Breath hold time, etc. Maximal mouth pressures are an essential indicator for changes in the pulmonary functions and mechanics. The most widely used methods of evaluation of pulmonary functions are the PFT's where the reduction in lung volumes, altered flow rates are all even

(Received 2nd September 2024; Accepted 10th January 2025; Published 19th January 2025)

dependent upon the changes in the thoracic pressure generated by the muscles of respiration which is mostly neglected in routine evaluation. Though it is an important OPD assessing tool for prescribing exercises to the patient having age related disease like cardiac or neurological involvement as well as the bedside assessment procedure for the patients in the ICU before weaning them from ventilators. The patients with dyspnoea, failure of the respiratory system, neurological affections like cerebrovascular accident, GBS, TBI, SCI and others have altered strength of the respiratory muscle (6). MIP (maximal inspiratory pressure); is for measuring the inspiratory muscle strength as it is measured when the individual actively draws in air starting from the residual volume. Likewise MEP (maximum expiratory pressure) is the phase that starts from the inspiratory capacity of the patient and continues towards the total lung capacity. Here, MIP is dependent on the negative thoracic pressure generated while the MEP is comparable to the elastic recoil of the alveoli followed by the force generated by the expiratory muscles too (7). The measurement of RMS depend upon multiple factors such as proper positioning of the patients as well as the measuring device, the second important factor is the performance while assessing which is multifactorial such as the perception of the procedure, the motivation while performing and the most important aspect is the accuracy and reliability of the device used for the assessment of the respiratory muscle strength (8). Several standardized tools are available for assessing respiratory muscle strength, particularly measured through maximal mouth pressures during both inspiratory and expiratory phase. The Micro RPM digital device, widely used for this purpose, offers accurate measurements but is often prohibitively expensive. As a result, many researchers have developed cost-effective and easily accessible diagnostic tools using manometers. However, these alternatives remain relatively unknown to clinicians, and as a result, the diagnosis of respiratory muscle strength continues to be neglected, despite its critical importance in patient care. These tests of respiratory muscle strength are instrument based and can be subjected to errors which could be due to machine or manual faults. It can-even be due to faulty techniques of measurement. Thus, there is an alternative to assess this strength of respiratory muscles which are based on the characteristics of an individual such as age, height, weight, etc. Which is a non-instrumental approach eliminating the possibilities of errors. These equations are applicable worldwide with a minimal difference in the characteristics included for evaluation of the strength for instance; some studies in Korean population where equation was proposed to measure respiratory strength included the handgrip strength of an individual as a parameter besides height and weight (9, 10). Every country has variability in the equations as well as respiratory muscle strength of their population (11, 12). There are studies suggesting of various equations to measure this strength of respiratory muscles which have variability. Similarly, an equation was even specifically proposed for calculating the maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) in Indian population (11). This respiratory muscle strength in terms of maximal respiratory pressures often remains undiagnosed due to lack of knowledge of its diagnostic tools. Universally as the literature suggests there are many (over more than fifty) reference equations proposed to identify the respiratory muscle strength. The impact of the equation used in assessing the strength of respiratory muscles plays a major role as the differences in prevalence of the weakness of these muscles ranges somewhere between 33-67 percentages (13). The present study thus aimed to assess applicability of the equation for evaluation of the respiratory muscle strength in one of the cities of India; so as to identify the usefulness of the equation proposed to diagnose the respiratory muscle weakness and propose an alternative tool while diagnosing the respiratory muscle strength in middle aged population.

Methodology

Study Design

This observational study was conducted post obtaining ethical clearance from the institutional ethics committee. The study was then registered with the CTRI with no: CTRI/2024/01/061911. A written as well as an informed consent was obtained from all participants while they were thoroughly informed about the use of their personal characteristics to identify the strength of

respiratory muscles. An importance of measuring the maximal respiratory pressures was explained to all the volunteers. The study was conducted from February 2024 till April 2024.

Participants

The participants who were healthy and were undiagnosed with any disease or underlying pathological condition, and even not receiving any treatment were enrolled for evaluation. The participants were all non-smokers. The subjects with any neurological, respiratory, thoracic abnormalities, acute cold or flu symptoms, the ones who demonstrated unwillingness, were all excluded from the study. The study cohort consisted of 200 participants, which were further divided into two groups separating males and females where each group consisted of 100 participants. All the volunteers were middle aged between 45-65 years. The personal details were assessed like age, weight and height for BMI calculation. A detailed history was taken pertaining to personal and medical conditions through a written questionnaire.

Anthropometric Measurement

The weight was measured wearing light clothes on the weighing scale and the height was evaluated barefoot with a wall fixed stadiometer. The BMI was calculated in kg/m^2 to include only the subjects who were with normal BMI.

Material Applicability

The maximal respiratory pressures were then evaluated in males and females separately using the equation (13). For males, MIP was measured using the following equation, MIP: 139.06 –Age (0.694) – Height (0.115) + Weight (0.190). Similarly, MEP was measured using the following: MEP: 170.59 – Age (0.627) – Height (0.443) + Weight (0.345). Females were evaluated for MIP with the formula as follows: MIP: 108.267- Age (0.406) – Height (0.191) + Weight (0.261). Likewise for measuring MEP the equation applied was MEP: 57.310 – Age (0.394) + Height (0.095) + Weight (0.233). For better results the measurements were recalculated by a second therapist who was blinded to the previous results. Further, we used SPSS 20 (SPSS, Inc., Chicago, IL, USA) for the statistical analysis. All data was expressed as mean ± standard deviation.

Results

The total of 200 volunteers (100 males and 100 female) were evaluated. The mean age was 56.67± 6.89 years for males and 58.45± 6.85 years for females. The average height of the males was 167.18 ± 3.99 and that of the females was 159.3 ± 2.74, measured in centimetres. The mean weight of the males was 69.14 ± 3.37 kg and 60.30 ± 4.08 kgs for the females. The mean BMI of the study cohort was 24.26±0.70 kg/m^2 (Table 1). The mean maximal inspiratory pressure for males is 93.63 ± 4.84 and maximal expiratory pressure is 84.84 ± 4.78 while the maximal inspiratory and expiratory pressures in females were 69.84 ± 2. 85 and 63.46 ± 2.86 respectively. (Table 2). The present study identified a negative correlation between age; the most influential variable in the respiratory muscle strength evaluation equation, and maximal respiratory pressures (MIP and MEP) (TABLE 3).

Table 1: Demographic Details of Volunteers

		N	Mean	Standard Deviation
AGE	Males	100	56.67	6.89
(years)	Females	100	58.45	6.85
HEIGHT (centimetres)	Males	100	167.18	3.99
	Females	100	159.3	2.74
WEIGHT	Males	100	69.14	3.37
(kilograms)	Females	100	60.30	4.08
Body Mass Index (BMI)	Males	100	24.76	1.44
(kg/m^2)	Females	100	23.76	1.57

Table 2: Maximal Respiratory Pressures

	N	Mean Inspiratory Pressure (MIP)	Mean Expiratory Pressure (MEP)
Males	100	93.63 ± 4.84	84.84 ± 4.78
Females	100	69.84 ± 2.85	63.46 ± 2.86

MIP and MEP are expressed as cmH_2O

Table 3: Correlation of Age and Respiratory Pressure

		MIP	MEP
	Pearson's correlation	-.350**	-.354**
	Sign. (2-tailed)	0.000	0.000
AGE	**N**	200	200

Discussion

There is various research conducted on proposing equation to identify the respiratory muscle strength (10-14). This study represents the first application of the equation to measure the maximal respiratory pressures to identify the respiratory muscle strength in middle aged males and females where the weakness of respiratory muscles can lead to comorbidities. The studies that proposed the reference equations for evaluation of these maximal respiratory pressures were all dependent primarily on the age of the subject. This is observed in the present study too which shows a negative correlation of age and the maximal pressure. This could be due to the change in the muscle mass as age advance which is initially referred to as sarcopenia. The maximal respiratory pressures are observed to be low as age advances which were even assessed by Maciel M *et al,* and colleagues in their study (15). Age which is the most dependent as well as the influencer variable shows a negative correlation with MIP and MEP. This possibly could be due to muscle mass and strength decrease with increasing age in men, with muscle mass often converting to fat mass. However, in females, overall strength may not be solely influenced by age (16, 17). The second major dependent factor influencing maximal respiratory pressure was the BMI. Some studies found a correlation between BMI and MIP as well as with MEP (12). While the studies conducted in India showed the higher correlation of maximal respiratory pressures directly with the height and weight parameters (13). It is known that the weight has a direct effect on the diaphragm which could reduce its efficiency leading to reduce respiratory functions. Various studies have shown variability in the outcomes depending upon the region studied. Thus, our study followed the equation which was region specific and dependent on age, height and weight of an individual. The results were similar consistent to those published in the literature. MIP in the present study for males was 93.63 compared to 96.16 in the literature and MEP was 84.84 while reported was 88.9. For females, MIP in the present study was 69.84 while it was 73.92 in the published literature and MEP was 63.46 compared to 66.67 published in the literature (18). Our present study indicated reduced maximal respiratory pressures which could be due to the difference in individual's personal characteristics. Thus, the equation can be effectively used to identify the respiratory muscle weakness considering these factors.

Conclusion

The equation used in the present study to evaluate the maximal respiratory pressure is a reliable tool for diagnosing respiratory muscle strength of an individual. The equation can further be used for identifying individual's cut off respiratory pressure for evaluation of respiratory muscle weakness. This equation can be valuable and of much significance while diagnosing neurologically affected patients for their respiratory muscle strength as it gives an individual's cut-off limit for inspiratory as well as expiratory muscle strength.

Future Recommendation

This equation can be applied to other age-groups to identify their respiratory muscle strength and even to various geographical locations. The effect of physical activity level should also be observed while evaluating the respiratory muscle strength.

Abbreviations

MIP: Maximum Inspiratory Pressure, MEP: Maximum Expiratory Pressure, COPD: Chronic Obstructive Pulmonary Disease, MND's: Motor Neuron Disease,FEV1: Forced Expiratory Volume in first second of expiration, PFT: Pulmonary Function Test, OPD: Out Patient Department, ICU: Intensive Care Unit, GBS: Guillan Barre Syndrome, TBI: Traumatic Brain Injury, SCI: Spinal Cord Injury, Micro-RPM: Micro Respiratory Pressure Meter, CTRI: Clinical Trial Registry of India, SPSS: Statistical Package for Social Science, BMI: Body Mass Index, N: number of participants.

Acknowledgement

I will be gratified to extend my thanks to the department of physiotherapy at Arush

Physiotherapy College, Ahmedabad for providing me the space to conduct my data collection. I would further take the opportunity to thank Dr Neelam Rathod H.O.D at Arush Physiotherapy College for the constant support.

Author Contributions

Dr. Tvisha Patel has designed the study with even preparation of the manuscript. The review of the protocol as well as the analysis of the data and interpretation of result was done by Dr Arvind Kumar. Dr Zarana Khamar recruited the participants and collected the data.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the study or this article.

Ethics Approval

The ethical approval was obtained post review by the Institute's ethical committee, Venus Institute of Physiotherapy: VIP/2023/EC/111. The trial is registered in Clinical Trial Registry- India: CTRI NO: CTRI/2024/01/061911.

Funding

The study has received no funding.

References

1. Fielding RA, Vellas B, Evans WJ, Bhasin S, Morley JE, Newman AB. Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. International Working Group on Sarcopenia. J Am Med Dir Assoc 2011;12(4):249-56. doi: 10.1016/j.jamda.2011.01.003.
2. Greising SM, Mantilla CB, Medina-Martínez JS, Stowe JM, Sieck GC. Functional impact of diaphragm muscle sarcopenia in both male and female mice. Am J Physiol Lung Cell Mol Physiol 2015;309(1): L46-52. doi: 10.1152/ajplung.00064.2015.
3. Baird JF, Sandroff BM, Motl RW. Therapies for mobility disability in persons with multiple sclerosis. Expert Rev Neurother. 2018 Jun;18(6):493-502. doi: 10.1080/14737175.2018.1478289. Epub 2018 May 30. PMID: 29772185; PMCID: PMC6291756.
4. Singer J, Yelin EH, Katz PP, Sanchez G, Iribarren C, Eisner MD, et al. Respiratory and skeletal muscle strength in COPD: impact on exercise capacity and lower extremity function. J Cardiopulm Rehabil Prev 2011;31(2):111. doi: 10.1097/HCR.0b013e3182033663.
5. Kim SH, Lee H, Kim Y, Rhee CK, Min KH, Hwang YI, et al. Recent prevalence of and factors associated with chronic obstructive pulmonary disease in a rapidly aging society: Korea National Health and Nutrition Examination Survey 2015–2019. J Korean Med Sci 2023;38(14):e108. doi: 10.3346/jkms.2023.38.e108.
6. Caruso P, Albuquerque AL, Santana PV, Cardenas LZ, Ferreira JG, Prina E, Trevizan PF, Pereira MC, Iamonti V, Pletsch R, Macchione MC, Carvalho CR. Diagnostic methods to assess inspiratory and expiratory muscle strength. J Bras Pneumol. 2015 Mar-Apr;41(2):110-23. doi: 10.1590/S1806-37132015000004474. PMID: 25972965; PMCID: PMC4428848.
7. Society ER, American Thoracic Society. ATS/ERS Statement on respiratory muscle testing. American journal of respiratory and critical care medicine. 2002 Aug 15;166(4):518-624. doi: 10.1164/rccm.166.4.518.
8. Silveira BMF, Pereira MCB, Cardoso DR, Ribeiro-Samora GA, Martins HR, Parreira VF. New method for evaluating maximal respiratory pressures: Concurrent validity, test-retest, and inter-rater reliability. Braz J Phys Ther. 2021 Nov-Dec;25(6):741-748. Doi: 10.1016/j.bjpt.2021.04.012. Epub 2021 May 14. PMID: 34119441; PMCID: PMC8721068.
9. Laveneziana P, Albuquerque A, Aliverti A, Babb T, Barreiro E, Dres M, Dubé BP, Fauroux B, et al. ERS statement on respiratory muscle testing at rest and during exercise. Eur Respir J. 2019 Jun 13;53(6):1801214. doi: 10.1183/13993003.01214-2018. PMID: 30956204.
10. Park TS, Tak YJ, Ra Y, Kim J, Han SH, Kim SH, Shin Y, Shin MJ, Kang JH. Reference Respiratory Muscle Strength Values and a Prediction Equation Using Physical Functions for Pulmonary Rehabilitation in Korea. J Korean Med Sci. 2023 Oct 16;38(40):e325. doi: 10.3346/jkms.2024.39.e78.
11. Pessoa IMBS, Houri Neto M, Montemezzo D, Silva LAM, Andrade AD, Parreira VF. Predictive equations for respiratory muscle strength according to international and Brazilian guidelines. Braz J Phys Ther. 2014 Sept-Oct; 18(5):410-418. Http://dx.doi. Org/10.1590/bjpt-rbf.2014.0044.
12. Lista-Paz A, Langer D, Barral-Fernández M, Quintela-Del-Río A, et al. Maximal Respiratory Pressure Reference Equations in Healthy Adults and Cut-off Points for Defining Respiratory Muscle Weakness. Arch Bronconeumol. 2023 Dec;59(12):813-820. doi: 10.1016/j.arbres.2023.08.016.
13. Nambiar VK and Savita R. Predictive Equations for Respiratory Muscle Strength among Urban Healthy Indian Adults. International Journal of Health Sciences and Research. 2015; 5: 180-185.
14. Rodrigues A, Da Silva ML, Berton DC, Cipriano G Jr, Pitta F, O'Donnell DE, Neder JA. Maximal Inspiratory Pressure: Does the Choice of Reference Values Actually Matter? Chest. 2017 Jul; 152(1):32-39. doi: 10.1016/j.chest.2016.11.045.
15. Maciel M, Silva C, Sanchez F, Marques J, Cortez P, Amaral C, Souza N, Gonçalves R. Respiratory Muscle Strength Evaluation in Healthy Adult and Elderly Women—Respiratory Muscle Strength Assessment in Adult and Elderly. Health. 2018; 10: 1031-1036.
16. Rietberg MB, Veerbeek JM, Gosselink R, Kwakkel G, van Wegen EE. Respiratory muscle training for multiple sclerosis. Cochrane Database Syst Rev. 2017 Dec 21;12(12):CD009424. doi: 10.1002/14651858.CD009424.pub2. PMID: 29267988; PMCID: PMC6486138.

17. Gopalakrishna A, Vaishali K, Prem V, Aaron P. Normative values for maximal respiratory pressures in an Indian Mangalore population: A cross-sectional pilot study. Lung India. 2011 Oct;28(4):247-52. doi: 10.4103/0970-2113.85684. PMID: 22084536; PMCID: PMC3213709.

18. Nambiar VK and Savita R. Maximal respiratory pressures and their correlates in normal indian adult population: a cross-sectional study. International Journal of Physiotherapy and Research ISSN 2321- 1822 2015; 3(4):1188-1196.