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Original Article

MAXIMAL RESPIRATORY PRESSURES AND THEIR CORRELATES IN NORMAL INDIAN ADULT POPULATION: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: The measurement of maximum static inspiratory pressure (MIP) and maximum static expiratory pressure (MEP) is important in the diagnosis of respiratory muscle dysfunction. There is a paucity of data done on MIP and MEP across the decades in Indian population to predict normal values for maximal respiratory pressures.

Materials and Methods: Five hundred subjects were selected through purposive sampling. Each age group had 100 subjects (50 males and 50 females). Pulmonary function tests and baseline data of demographic and anthropometric data of the normal subjects like age, height, weight and body mass index was recorded. The maximal inspiratory pressure (MIP) and Maximal expiratory pressure (MEP) was measured with a portable respiratory pressure meter (Micro RPM) using a standard protocol.

Results: MIP and MEP were studied across all decades and the mean values obtained were comparable with that of the Caucasian population in previous studies. Also MIP and MEP mean values were significantly higher in males as compared to females across the decades. Age showed a statistically significant negative correlation with both MIP and MEP with pearsons correlation coefficient. In males, MIP and MEP correlated negatively with height and weight. In females MIP correlated negatively with height and MEP correlated positively with height and weight.

Conclusion: The decade wise mean values obtained for MIP and MEP can be used as a reference to determine respiratory muscle strength in normal Indian adult population.

KEY WORDS: Maximal Respiratory Pressures, Adults, MIP, MEP, Normal Values, Reference Values.

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INTRODUCTION

Measurement of the maximum static inspiratory pressure that a subject can generate at the mouth (PI max) or the maximum static expiratory pressure (PE max) is a simple way to measure inspiratory and expiratory muscle strength. The pressure measured during these manoevers reflects the pressure developed by the respiratory muscles (P mus), plus the passive elastic recoil pressure of respiratory system including the lung and chest wall (P rs). These measures reflect global respiratory muscle strength for clinical evaluation as well as physiological studies. PI max is measured at or close to Residual volume (RV) & PE max at or close to total lung capacity (TLC) [1].

Residual volume is the volume of gas remaining in the lung after a maximal expiration.

Total lung capacity is the total volume of gas in the lungs after maximum inspiration [2].

Some of the basic tests used to assess pulmonary function depend not only on the lungs themselves but also on the respiratory muscles. TLC is the volume reached at the end of maximal inspiration, usually determined by lungs that cannot be expanded further, even by very large negative pressure, but if inspiratory muscles are weak, their maximum effort may not be enough to fully expand the lung.

Vital capacity is the volume of gas that can be exhaled after full inspiration [2]. Similarly if expiratory muscles are weak, they may not be able to compress the lungs to the normal residual volume. A low vital capacity (VC) or TLC can be a sign of either restrictive lung disease or weakness of inspiratory muscles, while a high residual volume can be a sign of either gas trapping from airway obstruction or expiratory muscle weakness. Therefore to find out if there is muscle weakness or lung disease, tests of respiratory muscle strength needs to be done, that are independent of the condition of the lung. They are independent of the condition of the lung. They are general tests of neuromuscular function of the combined diaphragm, abdominal, intercostal & accessory muscles [3].

MIP is indicative of ventilatory capacity and development of respiratory insufficiency. It is useful in assessing degree of abnormality and in monitoring inspiratory muscle weakness in individual patient's overtime. It evaluates the success of weaning patients from mechanical ventilation [4].

Assessment of the respiratory muscles ability to generate force is important for recognizing respiratory muscle weakness, both in sick and healthy people. In literature, there are many respiratory muscle strength measurement tools described some of which are invasive and non-invasive. Although the invasive techniques like gastric and oesophageal balloon technique are considered more reliable, they require difficult long and unpleasant procedure. Therefore non-invasive procedures, such as measurement of mouth or nasal pressure, which can be easily performed are preferred and widely accepted and applied [5]. The American Thoracic Society (ATS) / European Respiratory Society (ERS) have set guidelines for Respiratory muscle testing, where they have recommended the use of a digital manometer rather than an aneroid (mechanical) manometer. Currently there is only one commercially available handheld digital manometer specifically for Respiratory pressure measure-ment – the Micro RPM (Respiratory Pressure Meter) with a flanged mouth piece [6]. The maximal inspiratory pressure (MIP) and Maximum Expiratory Pressure (MEP) reflects the respiratory muscles ability to generate force during a short quasi-static contraction. MIP and MEP measurements are conducted with a manometer that measures mouth pressure and these depend on the motivation and co-ordination of the patient. Micro RPM is very portable and therefore can be used in clinic as well as bedside [5].

In a study done by Zacharias et al in 2011, the test – Retest Reliability of Maximum mouth pressure measurements were studied using micro RPM in healthy subjects. The MIP and MEP were measured both in sitting and standing positions. The intra-class correlation coefficient (ICC) obtained for most of the MIP & MEP measurements were higher than 0.8 indicating high reliability, suggesting its usage with high confidence in research & especially in clinical practice for assessment of MIP & MEP. The sitting position gave more reliable estimates than standing position [5].

Respiratory muscle weakness may be present in patients with dyspnea, respiratory failure, neuromuscular diseases, chronic respiratory diseases, metabolic diseases, prolonged corticosteroid treatment and prolonged ventilation. In advanced stages, respiratory muscle weakness leads to pump failure. There is decrease in strength and endurance of the respiratory muscles. Inspiratory muscle weakness results in dyspnea and exercise intolerance. Expiratory muscle weakness leads to mucus retention due to impaired cough efficiency [7].

Hence assessment of Respiratory Muscle Strength in terms of MIP and MEP is important as it serves as an indication for diagnosis, prognosis and in the implementation of Pulmonary Rehabilitation Programs.

There are many available studies that report reference values for MIP and MEP and also predictor equations. The different populations that have been studied are Caucasians, Iranians, Chineese, Malays, Brazilians, Asians, Thais, Columbia and other populations [8-13]**.** However there is a large variability between these different populations and also studies. The reference values for maximal inspiratory pressure and maximal expiratory pressure that we use for Indians are based on western population [14], as there are very scarce data available in Indian population**.** However the western reference values are not suitable clinically as there is a wide range of difference in race, genetic makeup and ethnicity.

Therefore it is necessary to establish normative reference values for maximal respiratory pressures (MIP and MEP) in Indian population. The aims and objectives of this study are 1) To obtain normative values for Maximal inspiratory pressure (MIP)and Maximal expiratory pressure (MEP) min Indian adults for both sexes across the age groups. 2) To determine the correlates for MIP and MEP.

MATERIAL AND METHODS

Study Design: Cross-sectional study, **Sample size estimation:** In a study carried out by S.M. Wilson et al in (1984) on predicted normal values for maximal respiratory pressured in Caucasian adults and children, the mean PI max in men were 106 cm H_2O and PE max was 148 cm H_2O. The mean PI max in women were 73 cm H_2O and PE max was 93 cm H_2O. Using standard deviation sample size for the present study has been estimated, based on a relative precision of 5% and desired confidence level at 95%. The estimated sample size worked out to be 135 for PE max and 197 for PI max.

Sample size: However in order to establish the normal values by gender and subgroup analysis, a minimum sample of 100 was taken in each subgroup (decade), and thus having a total of 500 subjects.

Sampling procedure for selection: Convenience sampling was carried out.

Inclusion Criteria for Normal Subjects: Males and Females across 18 to 70 years of age group. The population was divided into five groups with 100 subjects in each decade (50 males and 50 females), 18-29, 30-39,40-49,50-59 and 60-70 years. Total sample size was 500, Non Smokers and having normal Spirometric values.

Exclusion Criteria: Subjects with any Primary cardiac disease, history of Abdominal and Thoracic surgeries, Any neurological and musculoskeletal problems affecting respiratory pump mechanics and Any other condition that impairs the subjects ability to perform the test.

Materials used for the study was Weighing scale, Stadiometer, Micro RPM (Respiratory Pressure Meter), and Spirometer.

Procedure: Each subject underwent a formal evaluation program including Pulmonary function test and base line data of the demographic and anthropometric data of the normal subjects like age, height (cms), weight (kgs) and Body mass index (BMI) were recorded. Subjects were selected on the basis of inclusion criteria and written informed consent was taken from the subjects prior to the test. MIP in cms H_2O and MEP in cms H_2O was measured with portable Respiratory Pressure Meter (Micro RPM).

The subjects were seated with trunk at an angle of 90 degrees to the hip and feet on the ground. Subject used the nasal clip during all the manoevers. A nose clip was worn with normal mouth piece ensuring that there was no leak around the mouth piece. For MIP measurement, the subjects were asked to make a maximal inspiratory effort starting from residual volume (RV) and for MEP a maximal expiratory effort, starting from total lung capacity was performed. All the subjects performed three manoevers with effort and holding each for at least one second. One minute of rest was given between the efforts. The highest value recorded for MIP and MEP was taken for the purpose of data analysis.

Statistical Analysis: Statistical analysis was performed using SPSS software (version 18). Descriptive statistics such as mean, (± standard deviation) was computed to summarize the qualitative anthropometric data such as age, height, weight, BMI ,MIP and MEP for normal subjects. Independent student t-test stratified by gender was applied to compare mean scores of MIP and MEP between males and females. Pearsons Correlation co-efficient was used to study the association between MIP/ MEP and variables such as height, weight, age and body mass index among males and females.

RESULTS

The Anthropometric data of the study sample, mean and standard deviation for MIP and MEP in males are presented in **Table 1** and **Table 2** respectively. The Anthropometric data of the study sample, mean and standard deviation for MIP and MEP in females are presented in **Table 3** and **Table 4** respectively. Independent student t-test was carried out to compare mean MIP and MEP between males and females (**Table 5** and **Figure 4**). In males the mean MIP was 102.70 (±23.2) cms H_2O and MEP was 92.60 (±21.8) cms H_2O respectively. In females the mean MIP was 76.78 (±16) cms H_2O and MEP was 69.85 (±13.9) cms H_2O respectively.

Pearsons Correlation Co-efficient was computed to study the association between MIP/ MEP and variables such as height, weight, age and BMI. In **Males (Table 6)**, It was observed that MIP correlated negatively with height, pearsons correlation coefficient being -0.046 and p> 0.05 which was statistically not significant.

MIP correlated negatively with weight, pearsons correlation coefficient being -0.037 which was not statistically significant at p> 0.05.

MIP showed a negative correlation with age (-0.435) which was statistically highly significant at p< 0.001.

In case of MEP, pearsons correlation co-efficient between MEP and age, height and weight was negative with age and height showing statistically significant correlation (- 0.409,-0.172) respectively with p< 0.05.The correlation with weight was not statistically significant (-0.004) at p> 0.05.

Among **Females (Table 7)**, Age showed a statistically significant negative correlation with both MIP and MEP with pearsons correlation coefficient (-0.340) and (-0.373) respectively at p< 0.05.

MIP showed a negative correlation with height and a positive correlation with weight with pearsons correlation coefficient (-0.51 and 0.005) respectively at p>0.05.

MEP showed a positive correlation with height and weight, with pearsons correlation coefficient at (0.056,0.030) respectively at p>0.05.

In Males (**Table8**) ,BMI showed a positive correlation with both MIP and MEP with pearsons correlation coefficient (0.004,0.106) respectively which was not statistically significant at p>0.05.

In Females (**Table 9**), BMI showed a positive correlation with both MIP and MEP with pearsons correlation coefficient (0.034, 0.004) which was not statistically significant at p>0.05.

Thus Age was the variable that best correlated with both MIP and MEP in both males and females.

Table 1: Anthropometric data of the study sample by Male and age bracket.

	HEIGHT (cms)		WEIGHT (kgs)		BMI	
Age Group	Mean	±SD	Mean	±SD	Mean	±SD
18-29 Years	172.6	7.7	69.92	13	23.48	4.2
30-39 years	171.52	7.5	74.74	11	25.35	2.7
40-49 Years	166.68	16.9	74.04	8.4	29.65	25.8
50-59 years	173.56	6.7	77.4	9	25.67	2.4
60-70 Years	173.16	3.8	76.46	6.6	25.49	2.1
SD: Standard Deviation; BMI: Body Mass Index;						

Table 2: Maximal Respiratory Pressures (MIP and MEP) of the study sample in Males.

	MIP_BEST (cms of water)		MEP_BEST (cms of water)	
Age Group	Mean	±SD	Mean	±SD
18-29 Years	108.98	21.7	96.42	20.5
30-39 years	116.08	24.6	99.88	21.8
40-49 Years	105.64	16.2	104.94	16.3
50-59 years	106.72	17.6	94.6	12.7
60-70 Years	76.1	10.1	67.18	14
SD: Standard Deviation; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure				

Table 3: Anthropometric data of the study sample by Female and age bracket.

	HEIGHT (cms)		WEIGHT (kgs)		BMI	
Age Group	Mean	±SD	Mean	±SD	Mean	±SD
18-29 Years	158.5	6.3	58.86	11.2	23.39	3.9
30-39 years	159	7.8	65.64	10.2	25.99	3.9
40-49 Years	157.26	5.3	60.9	8.5	24.65	3.4
50-59 years	160.98	4.6	64.54	3.1	24.95	1.8
60-70 Years	158.54	4.2	68.78	6.6	27.37	2.7
SD: Standard Deviation; BMI: Body Mass Index;						

Table 4: Maximal Respiratory Pressures (MIP and MEP) of the study sample in Females.

	MIP_BEST (cms of water)		MEP_BEST (cms of water)	
Age Group	Mean	±SD	Mean	±SD
18-29 Years	83.26	16.7	73.92	13.9
30-39 years	78.9	19.1	75.3	16
40-49 Years	81.92	16.2	74.02	14.1
50-59 years	73.7	11	65.66	9.4
60-70 Years	66.14	8.6	60.34	9
SD: Standard Deviation; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure				

Table 5: Comparison of MIP and MEP between males and females (t-test).

	GENDER	N	Mean	Std. Deviation	P Value
MIP_BEST	Male	250	102.7	23.164	
	Female	250	76.78	16.003	<0.001
MEP_BEST	Male	250	92.6	21.747	
	Female	250	69.85	13.984	<0.001
Independent t test ; Degree of Freedom: 498 Value of MIP and MEP was statistically significant at p < 0.001					

Figure 1: Box plot showing comparison of mean age in males and females.

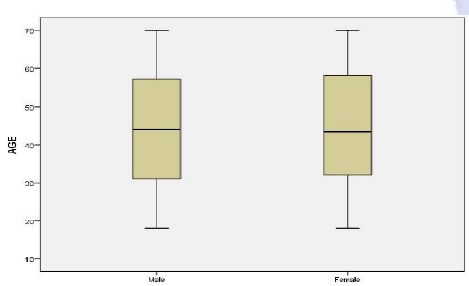


Figure 2: Boxplot showing comparison of mean Height in males and females.

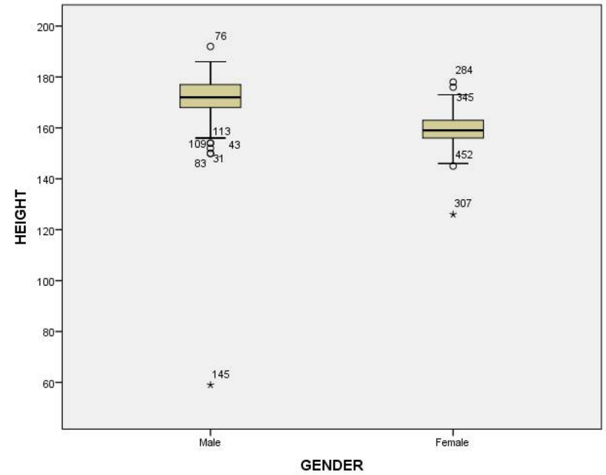


Figure 3: Boxplot showing comparison of mean weight in males and females.

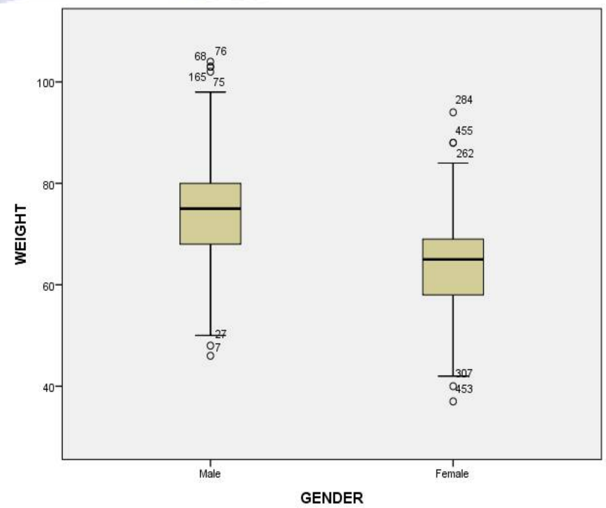


Figure 4 : Box plot comparing MIP and MEP between males and females.

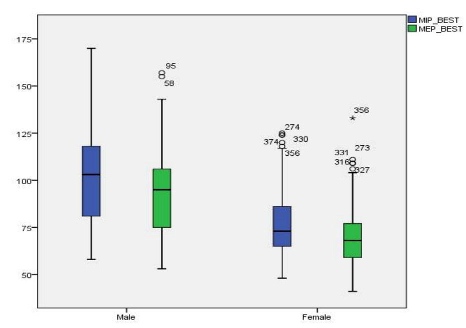


Figure 5: Scatter diagram for MIP and Age among males.

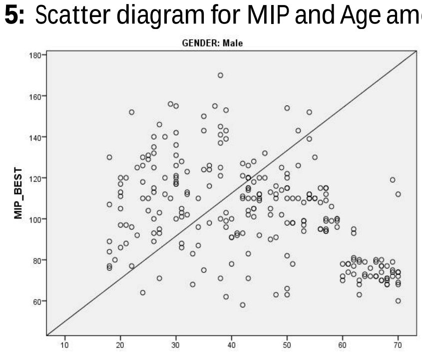


Table 6: Correlation of MIP and MEP with age,height and weight variables for Males.

		AGE	HEIGHT	WEIGHT	MIP_BEST	MEP_BEST
AGE	Pearson Correlation	1	0.051	.232**	-.435**	-.409**
	Sig. (2-tailed)		0.423	0	0	0
	N	250	250	250	250	250
HEIGHT	Pearson Correlation	0.051	1	.314**	-0.046	-.172**
	Sig. (2-tailed)	0.423		0	0.469	0.006
	N	250	250	250	250	250
WEIGHT	Pearson Correlation	.232**	.314**	1	-0.037	-0.004
	Sig. (2-tailed)	0	0		0.557	0.953
	N	250	250	250	250	250
MIP_BEST	Pearson Correlation	-.435**	-0.046	-0.037	1	.644**
	Sig. (2-tailed)	0	0.469	0.557		0
	N	250	250	250	250	250
MEP_BEST	Pearson Correlation	-.409**	-.172**	-0.004	.644**	1
	Sig. (2-tailed)	0	0.006	0.953	0	
	N	250	250	250	250	250

**. Correlation is significant at the 0.01 level (2-tailed). GENDER = Male

Table 7: Correlation of MIP and MEP with age, height and weight variables for females.

		AGE	HEIGHT	WEIGHT	MIP_BEST	MEP_BEST
AGE	Pearson Correlation	1	0.076	.316**	-.340**	-.373**
	Sig. (2-tailed)		0.23	0	0	0
	N	250	250	250	250	250
HEIGHT	Pearson Correlation	0.076	1	.320**	-0.051	0.056
	Sig. (2-tailed)	0.23		0	0.42	0.381
	N	250	250	250	250	250
WEIGHT	Pearson Correlation	.316**	.320**	1	0.005	0.03
	Sig. (2-tailed)	0	0		0.936	0.641
	N	250	250	250	250	250
MIP_BEST	Pearson Correlation	-.340**	-0.051	0.005	1	.576**
	Sig. (2-tailed)	0	0.42	0.936		0
	N	250	250	250	250	250
MEP_BEST	Pearson Correlation	-.373**	0.056	0.03	.576**	1
	Sig. (2-tailed)	0	0.381	0.641	0	
	N	250	250	250	250	250

**. Correlation is significant at the 0.01 level (2-tailed). a. GENDER = Female

Table 8: Correlation of MIP and MEP with Body Mass Index(BMI) in Males.

		BMI	MIP_BEST	MEP_BEST
BMI	Pearson Correlation	1	0.004	0.106
	Sig. (2-tailed)		0.954	0.095
	N	250	250	250
MIP_BEST	Pearson Correlation	0.004	1	.644**
	Sig. (2-tailed)	0.954		0
	N	250	250	250
MEP_BEST	Pearson Correlation	0.106	.644**	1
	Sig. (2-tailed)	0.095	0	
	N	250	250	250

**. Correlation is significant at the 0.01 level (2-tailed).a. GENDER = Male

Table 9: Correlation of MIP and MEP with Body Mass Index (BMI) in Female.

		BMI	MIP_BEST	MEP_BEST
BMI	Pearson Correlation	1	0.034	0.004
	Sig. (2-tailed)		0.591	0.951
	N	250	250	250
MIP_BEST	Pearson Correlation	0.034	1	.576**
	Sig. (2-tailed)	0.591		0
	N	250	250	250
MEP_BEST	Pearson Correlation	0.004	.576**	1
	Sig. (2-tailed)	0.951	0	
	N	250	250	250

**. Correlation is significant at the 0.01 level (2-tailed).
a. GENDER = Female

Figure 6: Scatter diagram for MIP and Age among females.

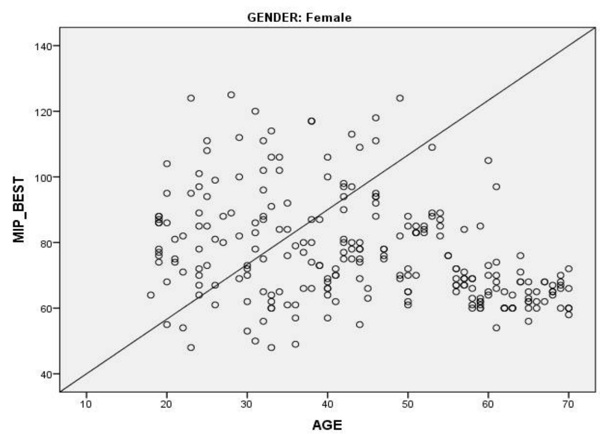


Figure 7: Scatter diagram for MEP and Age among males.

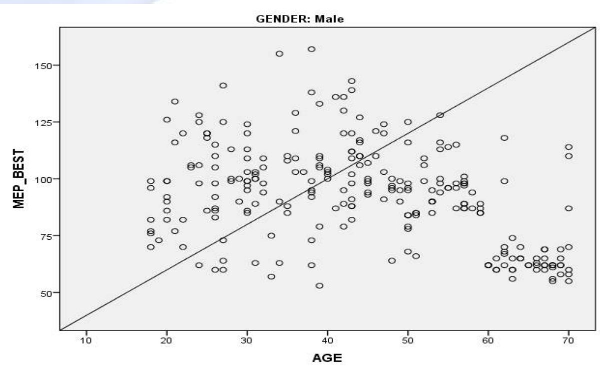
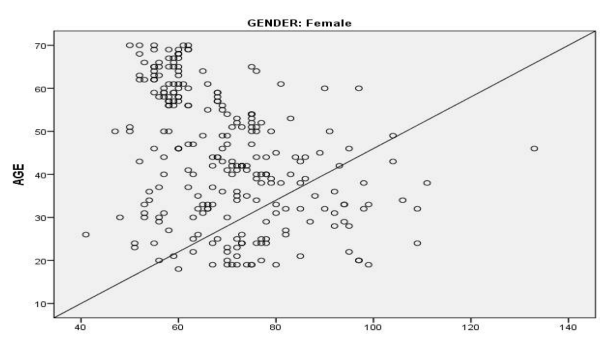


Figure 8: Scatter diagram for MEP and Age among females.



DISCUSSION

Considerable variations were seen in the maximal respiratory pressures reported in several studies. Comparing to all previous studies, in our study, the mean values of maximal respiratory pressures were comparable with Caucasian population [14]. The probable reason may be attributable to similar genetic makeup.

There may be several factors which contribute to the wide range of values obtained in the previous studies. The measurement of MIP and MEP would vary depending on the type of measuring device, the technique of measurement, type of the interface used, detectable air leaks and motivation level of the subject. During the measurement , if the subject has been using lot of buccinators muscle activity, which would not truly represent respiratory muscle strength, there would be an overestimation of values [13].

In a study done by Dayane Montemezzo et al in 2012 on "Influence of four interfaces in the assessment of Maximal Respiratory Pressures", the influence of four different interfaces on a subjects capacity to generate Maximal Respiratory Pressures (MRP) and the impact of these interfaces on the repeatability of these measurements were studied. 50 healthy subjects were evaluated and MRP was measured by using different mouth pieces and tubes. The analysed variables were maximum mean pressure, peak pressure, plateau pressure and plateau variation. MIP and MEP values were not influenced by the different interfaces used suggesting that availability of interfaces can be considered when measuring respiratory pressures [15].

Air leaks during the procedure were a part of the initial attempts, which were corrected subsequently by giving clear and proper instructions [16].

More the number of attempts given, higher maximal pressures were recorded. Thus in studies done by Ringquist [17], where there were more than ten attempts, higher values were recorded as compared to Black and Hyatt [18] who used two or three trials. Moreover in patients, it is practically impossible to give many attempts [19].

Moreover according to ATS/ERS Guidelines, digital equipment provides valid and highly accurate measures, and in our study the maximal respiratory pressures were measured using a digital manometer, thus providing greater accuracy [20].

On analysing the results of this study, it was seen that age and gender were the best correlates and predictors for MIP and MEP. Values for MIP and MEP were on an average, 26% and 23% higher in males compared to females, which was consistent with the study done by Simoes et al [21]. The percentage of lean body mass being higher in men could be probably one of the reason for this. It is reported that strength is proportional to the cross – sectional area of the muscle [22].

Age has a significant influence on maximal respiratory pressures. Age showed a negative correlation with both MIP and MEP in males and females which was statistically significant. This was consistent with almost all previous studies, where there was a decrease in maximal respiratory pressures (MIP and MEP) in both the genders which could be attributed to the aging process because of which there is increased residual volume and decreased inspiratory capacity leading to decreased MIP. The decrease in MEP could be due to the loss of elastic recoil of the chest cavity, presence of calcification in the joints, increased thoracic kyphosis thus leading to low rib cage compliance and hence decreased MEP which is based on total lung capacity .With advancing age there is also a decline in metabolic efficiency and nerve conduction velocity which also contributes to the decrease in the maximal respiratory pressures [22].

The muscle mass and the strength decreased with increasing age in men. The muscle mass gets converted to fat mass .However in females, the overall strength may not be related only to age [14].

Weight correlated positively with MIP in both males and females. Body mass index (BMI) also correlated positively with MIP and MEP with both genders. The pulmonary function and respiratory muscle strength increased with a small increase in body weight, which is called "Muscularity effect". In this effect both weight and muscle percentage correlated positively with one another, and also in isolation with MIP. The relationship of weight with MIP, is based on higher percentage of lean mass of respiratory muscles. In males, MEP correlated negatively with weight. Waist circumference is a positive predictor of MEP. The increase in visceral fat around the abdomen affecting the diaphragm mass influencing respiratory muscle performance could be the possible reason for the negative correlation between MEP and weight in males [22].

CONCLUSION AND IMPLICATIONS

The assessment of MIP and MEP can be used as a simple, quick, reproducible bedside clinical tool for evaluating respiratory muscle dysfunction. The decade wise mean values for MIP and MEP obtained for both males and females can be used as reference values (normative values) for assessing respiratory muscle strength. MIP and MEP can be used as a means of diagnosis, prognosis as well as monitoring the progress of the patients undergoing respiratory muscle training in the presence of respiratory muscle weakness.

LIST OF ABBREVIATIONS:

VC - Vital Capacity
TLC - Total lung capacity
MRP - Maximal Respiratory Pressures
MIP - Maximal Inspiratory Pressure
MEP - Maximal Expiratory Pressure
PI max - Maximal Inspiratory Pressure
PE max - Maximal Expiratory Pressure
ATS - American Thoracic Society
ERS - European Respiratory Society
RPM - Respiratory Pressure Meter
ICC - Intra class correlation coefficient
BMI - Body mass Index

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Conflicts of interest: None

REFERENCES

[1]. Dudley F Rochester. The respiratory muscles in COPD state of the Art. Chest 1984 June;85 suppl:47-50.
[2]. Tests of respiratory muscle strength. American journal of respiratory and critical care medicine 2002;166:528-543.
[3]. Weiner, Paltiel, McConnell, Alison. Respiratory muscle training in COPD: Inspiratory expiratory or both? Current opinion in pulmonary medicine 2005 March;11:140-144.
[4]. Wilson, Cooke, Edwards, Spiro. Predicted normal values for maximal respiratory pressures in Caucasian adults and children. Thorax 1984;39:535-538.
[5]. Johan, CC.Chan, Chia, Chan O.Y, Y.T. Wang. Maximal respiratory pressures in adult Chinese, Malays and Indians. European respiratory Journal 1997;10:2825-2828.
[6]. Van der Palen, Rea et al, Respiratory muscle strength and the risk of incident cardiovascular events. Thorax 2004 Dec;59(12):1063-1067.
[7]. Troosters.T, Gosselink.R, Deerames.M. Respiratory muscle assessment. European respiratory 2005;31:57-71.
[8]. S.H.Wilson, N T Cooke, RHTEdwards, SGSpiro. Predicted normal values for maximal respiratory pressures in Caucasian adults and children.Thorax 1984;39:535-538
[9]. A.Johan, C.C.Chan, H.P.Chia, O.Y.Chan, Y.T.Wang. Maximal respiratory pressures in adult chinese,malays and Indians.EurRespir J 1997;10:2825-2828
[10]. BabakAmra, HassanSalehi, SohrabSalimi, Mohammad Golshan. Reference values for maximal respiratory pressures.Tanafos 2005;4(14):19-23.
[11]. Nattha Muangritdech, Dr.WilaiwanKhrisanapant, Dr.Wannapa Ishida et al, A comparision of respiratory pressures in normal male and female Thai adults. Graduate Research Conference 2014;1633-1640.
[12]. Lida Maritza Gil Obando, Alexandra Lopez, Carmen Liliana Avila. Normal values of the maximal respiratory pressures in healthy people older than 20 years old in the city of Manizales-Columbia.Columbiamedica 2012;43(2):119-25.
[13]. Costa D, Goncalves HA, Lima LP, Ike D, Cancelliero KM, Montebelo MI. New reference values for maximal respiratory pressures in the Brazilian population. J Bras Pneumol 2010; 36:306-12.
[14]. A. Gopalakrishna, K. Vaishali, V.Prem, Praveen Aaron. Normative values for maximal respiratory pressures in an Indian Mangalore population: A cross-sectional pilot study. Lung India 2011;28:247–252.
[15]. DayaneMontemezzo et al. Influence of four interfaces in the assessment of maximal respiratory pressures.Respiratory care 2012;57(3):392-398.
[16]. Smyth RJ, Chapman KR, Rebuck AS. Maximal Inspiratory and expiratory pressures in adolescents. Chest 1984;86:568-72.

[17]. Ringqvist T. The Ventilatory capacity in healthy subjects: An analysis of causal factors with special reference to the respiratory forces. Scan J Clin Lab Invest Suppl 1996; 88 :5-179.
[18]. Black LF, Hyatt RE. Maximal respiratory pressure: Normal values and relationships to age and sex. Am Rev Respir Dis 1969;99:696-702.
[19]. Evan JA, White WA. The assessment of maximal respiratory mouth pressure in adults.Resp Care 2009;54:1348-59.
[20]. American thoracic society / European respiratory society ATS/ERS Statement on respiratory muscle testing. Am J RespirCrit Care Med 2002:166(4):518-629.
[21]. Simoes RP. Deus AP, Auad MA. Dionisio J, Mazzonetto M. Borghi-Silva A. Maximal Respiratory pressure in healthy 20 to 89 year old sedentary individuals of central Sao Paulo state. Rev Bras Fisioter. 2010;14(1):60-67.
[22]. Pessoa IMBS, HouriNeto M, Montemezzo D. Silva LAM, Andrade AD, Parreira VF. Predictive equations for respiratoty muscle strength according to international and Brazilian guidelines. Braz J PhysTher. http://dx.doi.org/10.1590/bjpt-rbf.2014.0044.

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