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Original Research Article

Predictive Equations for Respiratory Muscle Strength among Urban Healthy Indian Adults

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ABSTRACT

Background: The maximum static respiratory pressures measured at the mouth namely the maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) reflects the strength of the respiratory muscles. These are simple, non invasive clinical tool which has both diagnostic and prognostic value. **Objective:** To establish prediction equations for MIP and MEP for both genders based on the normal mean reference values in healthy Indian adults. **Methods:** 500 subjects in the age group of 18-70 years with normal pulmonary function test were studied. The MIP and MEP was measured with respiratory pressure meter and the best of three efforts was recorded. **Results:** We evaluated 250 men and 250 women. The equations were as follows:

MIP (cm H_2O) (Males) : 139.06 –Age* (0.694) – Ht^{+} (0.115) + Wt^{++} (0.190),

MIP (cm H_2O) (Females) : 108.267- Age* (0.406) – Ht^{+} (0.191) + Wt^{++} (0.261),

MEP (cm H_2O) (Males) : 170.59 – Age* (0.627) – Ht^{+} (0.443) + Wt^{++} (0.345),

MEP (cm H_2O) (Females): 57.310 – Age* (0.394) + Ht^{+} (0.095) + Wt^{++} (0.233)

* Age in years

$^{+}$ Height in centimetres

$^{++}$ Weight in Kilograms

Conclusion: In clinical practice, these equations could be used to calculate the predicted values of MIP and MEP for healthy Indian adults.

Key Words: Maximal Respiratory pressures, normal values, reference values, predictive equations, adults.

INTRODUCTION

The maximum static respiratory pressures (MRPs) measured at the mouth namely the maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) reflects the strength of the respiratory muscles. They are simple and non invasive clinical tool for measuring respiratory muscle strength which is of both diagnostic and prognostic value. [1] There is large inter-subject variability in MRP values. The characteristics of the population, equipment used and the technique of measurement all contribute to this variability. [2–8] 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, Chinese, Malays, Brazilians, Asians, Thais, Columbia and other populations. 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. However they are not suitable clinically as there is a wide range of difference in race, genetic makeup and ethnicity.

In order to standardize evaluation procedure, American Thoracic Society, European Respiratory Society (ATS/ERS) has published guidelines for the technique of measurement of MRP. [9] They stress the use of digital instruments to ensure the validity of measurements. MIP was measured from Residual volume (RV) and MEP was measured from Total lung capacity (TLC) in a sitting posture, air leaks were prevented around the mouth piece and a nose clip was used. The maximal pressure was sustained for one second. The best of three attempts was recorded as MIP and MEP in cms of H2O.

In this context, the aim of this study was to derive predictive equations for MIP and MEP based on the reference values for both genders in normal healthy individuals. [10]

MATERIALS AND METHODS

Sample size calculation was performed according to the published study. [10] A relative precision of 5% and desired confidence interval at 95% was adopted. In order to establish the normative values by gender and sub group analysis, a minimum sample of 100 was taken in each sub group (decade) and thus having a total of 500 subjects. The sample consisted of subjects of both genders selected randomly, who fulfilled all the inclusion criteria of the study. The inclusion criteria were as follows: Healthy adults between 18 to 70 years of age group, non-smokers with spirometric values within the predicted range. The exclusion criteria were as follows: 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. The study was approved by the Ethical Committee and participants signed the informed consent for the same.

Measuring Instruments: Micro RPM (Respiratory Pressure Meter), Weighing Scale, Stadiometer and Spirometer.

Procedure: Each subject underwent an initial evaluation which included pulmonary function test and demographical and anthropometric data of the normal subjects like Age, Height (cms), Weight (kgs) and Body Mass Index (BMI). MIP in cms H2O and MEP in cms H2O was measured with 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. A nose clip was used during all the maneuvers. For MIP measurement, subjects were asked to make a maximal inspiratory effort starting from Residual volume (RV) and for MEP, a maximal expiratory effort from Total lung capacity (TLC) was performed. Three efforts were carried out 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 the SPSS software (version 18). In all the subjects, the values for maximal respiratory pressures were plotted against the four variables measured (Age, Height, Weight and BMI). [10]

Subsequent to univariate analysis, those Independent Variables which showed statistically significant associations with

MIP and MEP were included into a linear regression model for deriving a Predictor Equation.

RESULTS

The anthropometric data of the study sample, mean and standard deviation for MIP and MEP were presented in Table1, Table 2, Table 3 and Table 4.

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	172.60	7.7	69.92	13.0	23.48	4.2
30-39 years	171.52	7.5	74.74	11.0	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	77.40	9.0	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	94.60	12.7
60-70 Years	76.10	10.1	67.18	14.0
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	158.50	6.3	58.86	11.2	23.39	3.9
30-39 years	159.00	7.8	65.64	10.2	25.99	3.9
40-49 Years	157.26	5.3	60.90	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	78.90	19.1	75.30	16.0
40-49 Years	81.92	16.2	74.02	14.1
50-59 years	73.70	11.0	65.66	9.4
60-70 Years	66.14	8.6	60.34	9.0
SD: Standard Deviation; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure				

Pearson's correlation coefficient was used to determine which variables would better explain the respiratory pressure values. [10]

In males, MIP and MEP both correlated negatively with height, weight and age. Whereas BMI showed a positive correlation with both MIP and MEP. Among females, MIP correlated negatively with age and height and a positive correlation with weight. MEP correlated negatively with age and positive correlation with height and weight. BMI correlated positively with both MIP and MEP.

The predictive equation was derived separately for males and females. Considering the predictive variables as age, height and weight, the regression equation for MIP and MEP were derived.

The following Equations for MIP and MEP are proposed for healthy Indian Adults.

MIP (cm H_2O) (Males): 139.06 –Age* (0.694) – Ht^+ (0.115) + Wt^{++} (0.190),

MIP (cm H_2O) (Females): 108.267- Age* (0.406) – Ht^+ (0.191) + Wt^{++} (0.261),

MEP (cm H_2O) (Males): 170.59 – Age* (0.627) – Ht^+ (0.443) + Wt^{++} (0.345),

MEP (cm H_2O) (Females): 57.310 – Age* (0.394) + Ht^+ (0.095) + Wt^{++} (0.233)

* Age in years

$^+$ Height in centimetres

$^{++}$ Weight in Kilograms

DISCUSSION

Different studies reported a wide range of variation in the maximal respiratory pressures (MRP). The age group between 18 to 70 years was studied with the aim of building prediction models for MRPs in healthy Indian adults. The reported mean value for MIP in males is (102.70+-23.2 cms H_2O) and for MEP is (92.60+-21.8 cms H_2O) and for MIP in females is (76.78+-16 cms H_2O) and for MEP is (69.85+-13.9 cms H_2O).

In this study, age height and weight showed correlations with maximal respiratory pressures. Black and Hyatt measured MIP and MEP in healthy subjects 20 to 80 years of age and derived equations based on age parameter. [11] In another study, the authors measured the same parameters in white individuals (adults and children) using age, height and weight to establish predictor equations. [12]

In the present study 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. [8] Since strength is proportional to the cross -sectional area and the percentage of lean body mass being higher in men could be probably one of the reason for the higher respiratory pressures. [1] Age has a significant influence on the maximal respiratory pressures. Age showed a negative correlation with both MIP and MEP in males and females which were statistically significant. This was consistent with almost all previous studies, where there was a decrease in maximal respiratory pressures in both genders which could be attributed to the aging process bringing about an increase in RV and decreased inspiratory capacity causing decreased MIP. The decrease in MEP could be due to loss of elastic recoil of chest cavity, calcification in joints, increased thoracic kyphosis leading to low rib cage compliance and thus decreased MEP, which is based on TLC. [1] Some authors state that the primary mechanism behind the decreased MRPs with age was sarcopenia. Also the respiratory muscle strength decreases approximately 8-10 percent per decade from the age of 40 onwards. [3]

In men, the muscle mass gets converted to fat mass with increasing age, thus contributing to decreased muscle mass and strength. However in females the overall strength may not be related only to age. [4]

Some authors explained the influence of weight on maximal respiratory pressures by attributing it to its relation with muscle mass, and alterations in weight could affect diaphragm mass and thus influencing respiratory muscle performance. [13]

The pulmonary function and respiratory muscle strength increased with a small increase in body weight which is called “Muscularity effect”. The relationship of weight with MIP is based on higher percentage of lean mass of respiratory muscles.

Waist circumference is a positive predictor of MEP. The increase in visceral fat around the abdomen affects the diaphragm mass, thus influencing respiratory muscle performance and contributing to the negative correlation between MEP and weight in males. [1]

There was a correlation of height with both MIP and MEP in males and females. This reflects an association between stature and respiratory muscle strength.

In the Regression formula proposed by Black and Hyatt, the best correlation was found with age variable. [14]

In Rodriguezs study, carried out on Venezuelan population, age and height were the variables included in the regression model. [15]

Age, gender and body surface area are the significant variables in the prediction equations in Italian population studied by Bruschi et al. [16]

Costa and Neder et al, observed that age and gender had greater predictive power and used them to determine predictive equations for respiratory muscle strength in Brazilian population. [7]

In this study, Regression analysis was used to obtain the prediction equations for maximal respiratory pressures and they were derived using age, height and weight as variables.

The reference values obtained for respiratory muscle strength and the proposed regression formulas are different in various studies, which could be attributed to factors like different device, anthropometric differences of biotype, race, nutrition, genetic makeup and physical activity.

CONCLUSION AND IMPLICATIONS

The results showed that the maximal respiratory pressures were lower than that found in International studies but matched that of Caucasian population. Age, gender and anthropometric characteristics (weight and height) are the variables that explain MIP and MEP values according to the proposed predictive models.

The predictive values allows the professionals to have standardized measures for decision making that could be used as reference values in the diagnosis and prognosis to treat individuals with Respiratory muscle weakness. Further plays an important in promoting aerobic capacity and endurance in any health condition, where the overall respiratory muscle strength is compromised, from a therapeutic and pulmonary rehabilitation perspective.

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Conflict of Interest: None

REFERENCES

1. Isabela M.B.S.Pessoa et al. Predictive equations for respiratory muscle strength according to International and Brazilian guidelines. Brazilian journal of physiotherapy.2014;http://dx.doi.org/10.1590/bjpt-rbf.20140044.
2. Hautmann H, Hefele S, Schotten K et al. Maximal inspiratory mouth pressures (PImax) in healthy subjects-what is the lower limit of normal? Respiratory Medicine.2000;94(7):689-93.
3. Costa D, Goncalves HA, Lima LP et al. Reference values for maximal respiratory pressures in the Brazilian population. J Bras Pneumol. 2010; 36(3):306-12.
4. Gopal krishna A, Vaishali K, Prem v et al. Normative values for maximal respiratory pressures in an Indian Mangalore population. A cross sectional pilot study. Lung India. 2011;28(4):247-52.
5. Vineken W, GhezzoH, Costo MG .Maximal static respiratory pressures in adults,normal values and their relationship to determinents of respiratory function. Bull EurPhysiopathol Respir. 1987;23(5): 435-9.
6. McConnell AK, Copestake AJ. Maximum static respiratory pressures in healthy elderly men and women.Respiration.1999; 66(3):251-8.
7. Neder JA, Andreoni .S, Lerario MC et al. Reference values for lung function tests: Maximal respiratory pressures and voluntary ventilation. Braz J Med Biol Res.1999;32(6):719-27.
8. Simoes RP, Deus AP, Auad MA et al. Maximal respiratory pressure in healthy 20 to 89 year old sedentary individuals of Central Sao Paulo State. Rev Bras Fisioter.2010;14(1):60-7.
9. AmericanThoracic Society/European RespiratorySociety.ATS/ERSstatement on respiratory muscle testing. Am J Respir CritCareMed.2002;166(4):518-624.
10. Veena Kiran Nambiar, Savita Ravindra. Maximal respiratory pressures and their correlates in normal Indian adult population: A cross-sectional study. Int J Physiother Res.2015;3(4):1188-96.
11. Black LF, Hyatt RE.Maximal respiratory pressures: normal values and relationship to age and sex. Am Rev Respir Dis.1969; 99(5):696-702.
12. Wilson SH, Cooke NT, Edwards RH. Predicted normal values for maximal respiratory pressures in caucasian adults and children. Thorax. 1984;39(7):535-38.
13. Arora NS, Rochester DF. Respiratory muscle strength and maximal voluntary ventilation in undernourished patients. Am Rev Respir Dis.1982;126(1):5-8.
14. 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. Columb Med 2012;43(2):119-25.
15. Rodriguez J, MantillaD, Lizarraga JP et al. Maximal inspiratory and expiratory pressures in normal adult individuals sanos. Valencia 2001-2002. Rev Salus online.2004;8(3):4-10.
16. BruschiC, CerveriI, Zoia M et al. Reference values of maximal respiratory mouth pressures: A population based study. Am Rev Respir Dis.1992; 146:790-3.

ANNEXURE

Table A: Coefficients and model summary for MIP in Males

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443[a]	.196	.186	20.897

a. Predictors: (Constant), WEIGHT, AGE, HEIGHT
b. Dependant variable: MIP_BEST

Coefficients

Model		Unstandardized Coefficients	
		B	Std. Error
1	(Constant)	139.064	23.337
	AGE	.694	.090
	HEIGHT	.115	.142
	WEIGHT	.190	.142

F = 19.9 ($p < 0.001$)

MIP (Males) : 139.06 – Age (0.694) – Ht (0.115) + Wt (0.190)

Table B: Coefficients and model summary for MIP in Females

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.366[a]	.134	.124	14.981
a. Predictors: (Constant), WEIGHT, AGE, HEIGHT b. Dependant variable: MIP_BEST				

Coefficients

Model		Unstandardized Coefficients	
		B	Std. Error
1	(Constant)	108.267	25.899
	AGE	-.406	.066
	HEIGHT	-.191	.171
	WEIGHT	.261	.116

F = 12.708 ($p < 0.001$)

MIP (Females): 108.267 – Age (0.406) – Ht (0.191) + Wt (0.261)

Table C: Coefficients and model summary for MEP in Males

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.460[a]	.212	.202	19.424
a. Predictors: (Constant), WEIGHT, AGE, HEIGHT b. Dependant variable: MEP_BEST				

Coefficients

Model		Unstandardized Coefficients	
		B	Std. Error
1	(Constant)	170.594	21.691
	AGE	-.627	.084
	HEIGHT	-.443	.132
	WEIGHT	.345	.132

F = 22.045 ($p < 0.001$)

MEP (Males): 170.59 - Age (0.627) - Ht (0.443) + Wt (0.345)

Table D: Coefficients and model summary for MEP in Females

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.406[a]	.165	.155	12.856
Predictors: (Constant), WEIGHT, AGE, HEIGHT Dependent variable: MEP_BEST				

Coefficients

Model		Unstandardized Coefficients	
		B	Std. Error
1	(Constant)	57.310	22.227
	AGE	-.394	.057
	HEIGHT	.095	.147
	WEIGHT	.233	.100

F = 16.201 ($P<0.001$)

MEP (Females) : 57.30 – Age (0.394) + Ht (0.095) + Wt (0.233)

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