Estimation of Inspiratory Muscle Strength in Normal Healthy Population and Its Correlation with Selected Physical Traits

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Abstract: ***Introduction**: The chief inspiratory muscle i.e. diaphragm is not used to its full potential in most of the adults, which may get weakened due to sedentary lifestyles and many other reasons. The objective of the present study was to investigate the estimation of the inspiratory muscle strength in normal healthy population and to find out its correlations with the selected physical traits. **Materials and Methods**: The study was conducted on purposively selected 816 healthy college students (483 males and 333 females) of Khalsa College, Amritsar, India, aged 17-26 years. The subjects underwent an assessment including the measurements of the maximal inspiratory pressure, measurement of height, weight, chest circumference, neck circumference, biacromial breadth and trunk length. Age of the subjects was confirmed from their respective dates of birth from the college records. **Results**: The results of the study showed significant differences between the male of female students for all the variables ($p \leq 0.001$) estimated by one way analysis of variance. Both in male and female students,, significant correlations ($p \leq 0.001$) of inspiratory muscle strength with the selected physical traits were found. **Conclusion:** The conclusion drawn from the study results stated that the inspiratory muscle strength of normal healthy subjects was reported to be significantly varied in the males and females and was significantly correlated to the studied physical traits of the subjects.*

Keywords: Inspiratory muscle strength. Maximal inspiratory pressure. Physical traits

1. Introduction

1) The diaphragm, often forgotten muscle, is one of the most important muscles in terms of athletic performance. This is a muscle that can easily get weaken because of number of reasons, allowing secondary muscles to take over its primary duty. In fact, most adults do not use their thoracic diaphragm to its full potential due to weakening of the muscle that arises from sedentary lifestyles. Instead, they primarily rely on secondary muscles to control breathing, which in turn causes inefficient oxygenation of the blood. It has been observed in a number of studies that the normal subjects are unable to reach the MIP reference values (Aldrich and Spiro, 1995; Mcelvaney et al., 1989; Enright et al., 1994; Smyth et al., 1984; Black and Hyatt, 1969).

2) Maximal inspiratory pressure (MIP), also known as negative inspiratory force (NIF), is the maximum pressure that can be generated against an occluded airway beginning at functional residual capacity (FRC). This pressure generated by the inspiratory muscles, is responsible for volume changes in the respiratory system (Gibson, 1999). It is a marker of inspiratory muscle function and strength (Irwin, 2008), represented by centimeters of water pressure (cmH_2O). Maximum inspiratory pressure is an important and non-invasive index of diaphragm strength and an independent tool for diagnosing many illnesses (Sachs et al., 2009). Typical maximum inspiratory pressures in adult males can be estimated from the equation, MIP = 142 - (1.03 x Age) cmH_2O, where age is in years (Wilson et al., 1984).

3) The common indications for measurement of the MIP include respiratory muscle weakness, such as a patient with unexplained dyspnea, a weak cough, or known neuromuscular disease; reduced vital capacity (VC) shown in lung function tests or an increased diffusion capacity of unknown etiology and evaluation of whether known respiratory muscle weakness has improved, remained stable, or worsened.

4) The anthropometric traits like chest circumference and expansion, chest depth and trunk length can be related to the strength of inspiratory muscles because the increase in the thoracic cage diameters during inspiration is directly related to the contraction of the diaphragm. Along with the lungs, the chest wall is an elastic structure and follows the displacement of the lungs. Measurement of the thoracic expansion with a measuring tape has been used as a chest wall mobility index in healthy subjects (Enright and Unnithan, 2011) as well as in patients. (Enright et al., 2004).

5) Keeping the above points in view, this study was done to investigate the values of inspiratory muscle strength in normal healthy population and to find out its correlations with the selected physical traits.

2. Materials and Methods

1) Participants

The study was carried out in the Department of Physiotherapy, Khalsa College, Amritsar, India after taking approval from institutional ethics committee. The study was conducted on 816 healthy subjects, out of which 483 were males and 333 were females aged 17-26 years. The study procedure was explained to the participants and signed informed consent forms were taken from the subjects. The subjects' age was confirmed from their dates of birth. The subjects were excluded if presented with any history of cardiorespiratory problem, thoracic surgery or acute common cold or flu. The assessment of the subjects was done during the common college timings of 9:00 am to 4:00 pm.

2) Measurement of inspiratory Muscle Strength

The inspiratory muscle strength was assessed by assessing the maximal inspiratory pressure, which represents the strength of the inspiratory muscle. The measurement of maximal inspiratory pressure was taken using a hand held digital device known as 'Respiratory Pressure Meter' (RPM). The measurements were taken in the sitting position with trunk straight. The participants were instructed to hold the mouthpiece of the RPM in the mouth and inhale maximally through mouth. A nose clip was applied to the participants' nose. The readings of maximal inspiratory pressure were taken from the digital meter on the RPM at the end of inspiration. A total number of three readings were taken from each subject and the best of the three was selected.

3) Anthropometric Measurements

The assessment techniques mentioned by Lohmann et al. (1998) were used to measure the various physical traits of the subjects and were measured in triplicate with the median value used as the criterion. The weight of the subjects was taken in minimal light-weight clothing, bare foot, using standard weighing machine and the reading was taken in kilograms. Stadiometer (Holtain Ltd. Crymych, Dyfed, UK) was used for measuring the standing height of the subjects. The subjects stood with bare feet on the horizontal surface by heel touching the ground and the counter board of the stadiometer was brought down till it touches the vertex of the subjects. The height of subjects was recorded in centimetres. The chest and neck circumference was measured by the measuring tape. The chest circumference was measured at the level of the nipples at the end of normal expiration. The neck circumference was taken at the level of base of neck. The biacromial breadth and trunk length were measured with the help of an anthropometric rod. For the biacromial breadth, the distance between the two acromion processes was measured. For the trunk length, the distance between the acromion process and the anterior superior iliac spine of the right side of the subjects were measured in centimetres.

4) Statistical Analysis

The descriptive statistics (mean ± standard deviation) were determined for all the variables. Student's t-test was used for comparing the data of the male and female groups. The data was analyzed to obtain the correlation coefficients of the maximal inspiratory muscle strength with the rest of the studied variables. A 5% level of probability was used to indicate the statistical significance.

3. Results

1) The descriptive statistics of the maximal inspiratory pressure and selected anthropometric variables of subjects were shown in table 1. Student's t-test showed significant differences ($p \leq 0.001$) between male and female students in all the variables studied.

Table 1: Descriptive statistics of maximal inspiratory pressure and selected physical traits in normal healthy male and female students

Variables	Male students (n=483)		Female students (n=333)		t value	p value
	Mean	S.D.	Mean	S.D.		
Maximal inspiratory pressure (cmH_2O)	79.45	26.52	49.60	17.61	17.984	<0.001
Height (cm)	173.48	6.61	159.43	6.16	30.705	<0.001
Weight (kg)	68.44	12.04	54.29	10.42	17.421	<0.001
Chest circumference (cm)	90.76	8.16	84.59	8.24	10.573	<0.001
Neck circumference (cm)	38.43	2.62	32.81	2.15	32.335	<0.001
Biacromial breadth (cm)	32.92	2.36	28.94	2.75	22.129	<0.001
Trunk length (cm)	44.28	2.37	41.04	2.26	19.534	<0.001

2) The correlation coefficients of maximal inspiratory pressure with selected physical traits in male and female students were shown in table 2. In male students, the maximal inspiratory pressure had statistically significant positive correlations with weight ($p<0.001$), chest circumference ($p<0.001$) and neck circumference ($p<0.001$). In the case of female students, the inspiratory muscle strength had statistically significant positive correlations with age ($p<0.007$), weight ($p<0.001$), chest circumference ($p<0.001$) and biacromial breadth ($p<0.004$). In the combined values of male and female students, the maximal inspiratory pressure showed statistically significant positive correlations ($p<0.031$-0.001) with all the studied variables.

Table 2: Correlation coefficients of maximal inspiratory pressure with selected physical traits in male and female students

Variables	Male Students (n=483)		Female Students (n=333)		Combined (n=816)	
	r	p	r	p	r	p
Age (years)	0.008	0.854	0.147	<0.007	0.075	<0.031
Height (cm)	-0.008	0.858	-0.021	0.702	0.384	<0.001
Weight (kg)	0.209	<0.001	0.211	<0.001	0.428	<0.001
CC (cm)	0.218	<0.001	0.236	<0.001	0.359	<0.001
NC (cm)	0.192	<0.001	0.081	0.140	0.490	<0.001
BB (cm)	0.070	0.126	0.159	<0.004	0.392	<0.001
TL (cm)	0.056	0.221	0.005	0.926	0.329	<0.001

MIP = Maximal inspiratory pressure, CC = Chest circumference, NC = Neck circumference, BB = Biacromial breadth, TL = Trunk length.

4. Discussion

1) The inspiratory muscle strength is related to fitness and individual ventilatory capacity. Respiratory muscle weakness can lead to reduced exercise capacity and respiratory insufficiency (Simoes et al., 2010). In the present study, the respiratory muscle strength was assessed by assessing the maximal inspiratory pressure. The history of evaluating the respiratory muscle strength with the help of maximal respiratory pressures dates back to 1960s (Simoes et al., 2010). This non-invasive method of assessing the respiratory muscle strength is fast, practical and low-cost method of evaluation in healthy as well as diseased

individuals (Johan et al., 1997; Kim and Sapienza, 2005; Steier et al., 2007; Harik-Khan et al., 1999).

2) The present study evaluated the maximal inspiratory pressure in male and female students aged 17-26 years and findings of the study showed that the mean values of the males were significantly higher than the mean values of the females. The findings of the present study are in close agreement of the earlier studies which stated that the respiratory muscle strength is affected by many factors which includes age, gender and race.

3) The findings of the present study indicated that there were statistically significant positive correlations of maximal inspiratory pressure with the studied variables namely age, height, weight, chest circumference, neck circumference, biacromial breadth and trunk length. The findings of the present study followed the direction of the findings of Schoenberg et al. (1978). The study stated that that weight exerted a certain influence on respiratory muscle strength, because as body weight increased the volume and size of respiratory muscles increased, which improved the strength of these muscles and ventilatory function.

4) This study finding is also supported by earlier studies (O'Brien and Drizd, 1983), the results of which explain that in the taller individuals, the respiratory muscle strength is higher. This may be due to the relationship between pulmonary volume and maximal respiratory pressures. It also stated that pulmonary volume has a direct relationship with height, considering that the highest values of maximal inspiratory and expiratory pressures are generated with the smallest and largest pulmonary volumes, respectively. It can be inferred that maximal respiratory pressures are dependent on pulmonary volume and, consequently, the latter are dependent on the individual's height.

5. Conclusion

The conclusion drawn from the results of the study could be stated as there were significant differences in the values of inspiratory muscle strength and selected physical traits between the male and female students. The inspiratory muscle strength was reported to be significantly correlated with selected physical traits viz. age, height, weight, chest circumference, neck circumference, biacromial breadth and trunk length in normal healthy male and female college students.

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