# **Original Research Article**

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# Does obesity affect the respiratory muscle strength? An observational study

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# **ABSTRACT**

**Background:** Obesity is a condition where the energy intake exceeds energy expenditure of the body. Obesity is seen to affect different aspects of life both physically and emotionally. One such physical aspect is the breathing pattern. Studies on the behavior of respiratory muscle strength (RMS) in obese patients have found conflicting results.

Methods: Using purposive sampling, 60 subjects who fulfilled the inclusion criteria were recruited in the study. Each individual was subjected for the assessment of Maximal Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP), Body Mass Index (BMI) and Waist circumference (WC).

Results: A Pearson's product-moment correlation coefficient showed a positive correlation between MIP and WC  $(r=0.378, n=60, p=0.003 \text{ with } \alpha \text{ at } 0.01)$  and between MEP and WC  $(r=0.288, n=60, p=0.026 \text{ with } \alpha \text{ at } 0.05)$ . There was no correlation found between BMI and MIP (r=0.138, n=60, p=0.292) and BMI and MEP (r=0.150, n=60, p=0.252).

Conclusions: The findings of the study suggest that the respiratory muscle strength is more in individuals with higher waist circumference values whereas with BMI it is inconclusive.

Keywords: Maximal expiratory pressure, Maximal inspiratory pressure, Respiratory muscle strength, Waist circumference

#### INTRODUCTION

Obesity is a metabolic condition which occurs when there is an imbalance between the energy supply and energy demand of the body. This imbalance between the energy intake in terms of nutrition and energy expenditure in terms of physical activity leads to excess deposition of fat in the body. Because of the excess body fat accumulation, there occur various physiological changes leading to adverse health consequences. Hence, Obesity is said to be the disease of the 21st century.1 Obesity has various effects on the body of an individual. The physiological effects are evident on various systems of the body such as metabolic pathways, respiratory system, cardiac system, gastrointestinal system, etc. Obesity is also associated

with co-morbidities such as type 2 diabetes, hypothyroidism, respiratory dysfunction cardiovascular diseases to name a few.2

One more important factor which plays an important role in the prevalence of diabetes at present is the change of lifestyle which happened over the last 30 years. Increase in the sedentary behaviour was a secular trend reported by the census of 2005. WHO has predicted that the by 2030, the number of overweight individuals would be 1.35 billion worldwide.3

Researchers have found obesity to be related to reduced inspiratory muscle strength which leads to increase in the inspiratory effort, more oxygen consumption and high

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energy expenditure, all of which contribute to high diaphragm fatiguability. 4.5 In contrast, many researches performed on respiratory muscle strength (RMS) of morbidly obese individuals have presented conflicting evidence. Where there is conclusive evidence which has shown that RMS is not associated with obesity and BMI and were within the bounds of normality when compared to eutrophic individuals, that excess body weight does not change the respiratory muscle mechanics, few studies have shown increase of RMS in morbidly obese individuals. 7-10

There is a lack of consensus regarding the influence of obesity on RMS. Inspiratory muscle endurance has not yet been investigated in obese individuals. One study showed a significant association between body weight and inspiratory muscle endurance, assessed by inspiratory resistance exercises in normal healthy children and adolescents. <sup>11</sup>

The effects of obesity on inspiratory muscle endurance have not yet been linked and studied with inspiratory resistance in obese individuals. The present study was performed to find out if there exist a relationship between obesity and respiratory muscle strength.

#### **METHODS**

The ethical approval was obtained from the ethics approval committee. The study design was observational analytical study. The inclusion criteria for recruitment of subjects was age between 18-45 years both males and females. Individuals with existing respiratory or cardiac disease, any spinal deformity, who have undergone spinal surgery and neural deficits and radiculopathy were excluded from the study. Subjects who fulfilled the inclusion and exclusion criteria were selected. An informed written consent was taken from all subjects. Using purposive sampling, 60 subjects were recruited in the study. All subjects were assessed for Maximum Inspiratory Pressure, Maximum Expiratory Pressure, Body Mass Index and Waist circumference. Annexure -A was filled by the therapist who recorded all the parameters.

Maximum inspiratory and expiratory pressure was measured by MicroRPM<sup>TM</sup> device. The subjects were seated with trunk at an angle of 90 degrees to the hip and feet on the ground. Subject used the nose clip during all the manoeuvres. A nose clip and mouth piece was worn ensuring that there was no leak around the mouth piece. For MIP measurement, the subjects were asked to exhale completely and make a maximal inspiratory effort starting from residual volume (RV) and held for minimum of 1 second. For MEP, patient was asked to take a maximal deep breath in and exhale forcefully from total lung capacity (TLC) through the mouth piece. All the subjects performed three manoeuvres with effort and best of all the 3 readings was taken according to American Thoracic Society (ATS) guidelines.<sup>12</sup> Body Mass Index was measured using height and weight measurement. Height was measured using stadiometer Subject was made to stand on the stadiometer with eyes at horizontal level and shoulders, hips and ankles close to the wall. A device headpiece was kept at the vertex horizontally and height was measured. Weight was measured by weighing machine

BMI Calculation= weight (kg) / height2 (m).<sup>13</sup>

Waist circumference was measured by tape. The tape was kept at the narrowest part of the waist, usually at belly button at a proper fit (not too tight or too loose). <sup>14</sup>

Data analysis was done using the Statistical Package for the Social Sciences (SPSS) version 21 software. The measurement variables were subjected to descriptive and inferential analysis. A Pearson's product-moment correlation coefficient was computed to assess the relationship between MIP and MEP value with BMI and WC measurement.

#### **RESULTS**

Sixty normal, healthy subjects were recruited for the study (15 males and 15 females) had a mean age, height, weight of  $28.65\pm7.36$  years,  $163.93\pm8.94$  cms and  $63.42\pm10.77$  kgs respectively. The demographic details are presented in Table 1.

Table 1: Demographic data of subjects (mean  $\pm$  sd)

Age	Gender	Height	Weight
28.65±7.36	M-15/	163.93±8.94	63.42±10.77
	F-15		

A Pearson's product-moment correlation coefficient was computed to assess the relationship between MIP value and WC measurement. There was positive correlation between the two variables, r=0.378, n=60, p=0.003 with  $\alpha$  at 0.01. (Table 2) (Figure 2).

Table 2: Correlation of WC and MIP.

	P value	R value	N
WC and MIP	0.003	0.378	60

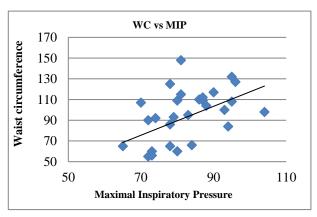


Figure 2: Correlation between WC and MIP.

Similarly, a Pearson's product-moment correlation coefficient was computed to assess the relationship between MEP value and WC measurement.

There was a positive correlation between the two variables, r=0.288, n=60, p=0.026 with  $\alpha$  at 0.05 (Table 3) (Figure 3).

Table 3: Correlation between WC and MEP.

	P value	R value	N
WC and MEP	0.026	0.288	60

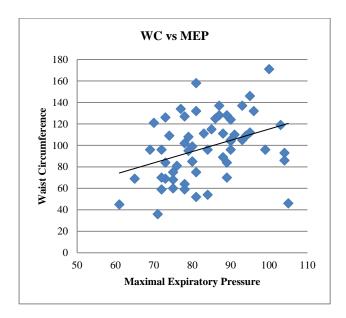


Figure 3: Correlation between WC and MEP

Overall, there was a positive correlation between the MIP and MEP values and waist circumference.

To find the correlation between BMI and MIP and MEP values, a Pearson's correlation was computed.

For BMI and MIP, r=0.138, n=60, p=0.292 (Table 4) (Figure 4).

Table 4: Correlation between MIP and BMI.

	P value	R value	N
MIP and BMI	0.2	0.138	60

Table 5: Correlation between MEP and BMI.

	P value	R value	N
MEP and BMI	0.252.	0.150	60

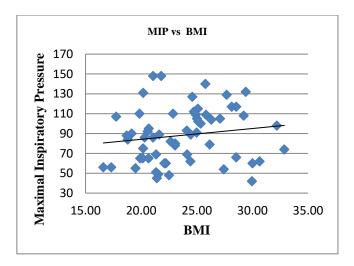


Figure 4: Correlation between BMI and MIP

For BMI and MEP, r=0.150, n=60, p=0.252 (Table 5) (Figure 5).

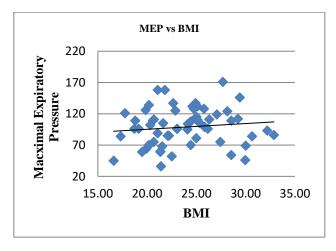


Figure 5: Correlation between MEP and BMI

The results showed that there was no correlation between BMI and MIP and MEP values.

## **DISCUSSION**

Present study found that waist circumference correlated moderately with MIP values and weakly correlated with MEP values. The findings suggested as abdominal girth increases, maximal inspiratory and expiratory pressure increases (Refer Table 2 and 3). The increase in MIP in obese women is ascribed to deposition of fat around the abdomen and chest which leads to a stiffer and less complaint chest wall. Due to these structural changes, there is increased load against which diaphragm acts. These continuous high demands on the diaphragm leads to adaptation of the muscle. Hence for adequate ventilation, respiratory muscles get adjusted to work against extra load which is the fat deposition. These findings are in agreement with a study done by Pazzinoto et al which evaluated respiratory muscle strength in morbidly obese women. Findings revealed that inspiratory muscle strength was greater in morbidly obese women than normal weight women. This could be the probable cause of high MIP and MEP values with increase in the waist circumference. A study undertaken by Costa et al showed findings equivalent with the present study where correlation was studied between respiratory muscle strength and WC and WHR of 103 women out of which 57 were obese and 46 normal-weight women. If

A study performed by Wilaiwan Khrisanapant et al is in line with findings of our study where the authors studied the relationship of obesity in Thai women. It suggested that the greater MIP and MEP values obtained in obese women could be due the compensation occurring. Due to the increased work done by the muscles in this condition, the diaphragm and abdominal muscles undergo plasticity. These changes occur because of the demands placed on it. In obesity, the muscle fibre composition changes wherein type 2 fibres are more in number and recruited more often as the muscles work against a high load. Hence, force generation is better.<sup>17</sup> Although the activity of TrA is not modulated with quiet breathing, it is the first abdominal muscle recruited when expiration is increased with chemical drive or elastic loading. In addition, the timing of the postural contraction of TrA, but not RA and OE, varied across the respiratory cycle when respiration was challenged by an inspiratory load. More recently, it has been argued that TrA, but not the other abdominal muscles (OI, OE, and RA), may have separate populations of motor units for postural and respiratory functions. Such an organization provides a potential mechanism to simplify the coordination of postural and respiratory functions, but this hypothesis has been based on investigation of a limited population of motor units and requires corroboration. Cezar et al support the above findings in their study. They explained their findings in view that the muscles of obese individuals have distinct metabolic and histological characteristics, which show an increase in lean muscle mass and therefore a stronger muscle contraction. Due to the attempts to maintain the body upright and daily physical efforts for body movements in a controlled way, obese individuals have higher proportion of type 2 fibres in skeletal muscle mass.18

Magnani and Cataneo concluded in their study that respiratory muscle strength does not get hindered by obesity. <sup>19</sup> Similar findings were achieved by Queiroz et al where MIP values of obese group were more than MIP values of non obese group. <sup>20</sup> Many similar studies have shown android obesity is chiefly fat in the abdominal region associated with higher MIP values.

When performing any forced manoeuvre, muscles are the active participants in stabilization as well as power generation. In obese individuals, the function of stabilization is somewhat overtook by the adiposity, making the chest wall rigid than normal chest wall compliance. Hence, the muscles work against this excess

load more forcefully as one component is being taken care by other mechanism. In contrast, Kelly et al examined the maximum inspiratory and expiratory pressures at different lung volumes in 45 morbidly obese patients. These were compared with the pressures of 25 non-obese age-matched individuals. At all lung volumes, the pressures generated by the obese patients were lower than those of the non obese subjects, despite heightened demands for diaphragmatic work. This may result from diaphragm dysfunction.<sup>21</sup> These findings could be described depending on the area of fat distribution. As BMI was the measure used to find the relationship between obesity and respiratory pressures, numerous studies have concluded that it gives the overall distribution of fat deposition. These findings are in dissimilarity from our findings for reason that present study focused on more reliable measure i.e. waist circumference.<sup>22</sup>

In addition, another indirect action by which we achieved these findings could be accredited to abdominal adiposity showing similar behaviour as abdominal binding. The stiffness provided by the fat deposition could be on similar line by effectively increasing both insertional and appositional forces on the diaphragm thus making the effort more strong and improving neuromuscular efficiency. Studies supporting this mechanism are limited, hence inconclusive.

In the present study, there was no significant correlation found between BMI and MIP and MEP values. While the term 'obesity' generally refers to an excess of body fat, most data regarding the effects of obesity on health rely on measurement of body weight. Body mass index (BMI) is a commonly used measure of adiposity because it is readily measurable and correlates with adverse outcomes such as vascular disease and the development of diabetes mellitus. However, BMI does not adequately describe the distribution of fat nor does it directly measure body composition. This could be reason behind our findings as BMI was not sufficient to find a correlation with respiratory muscle strength. A review article by Aparna Chandrashekharan supports the fact that BMI should always be used with other more accurate measures of obesity as it should not be only criteria to find association between obesity and other variables.<sup>23</sup> In this view, the correlation between BMI and VMS could not be established

#### CONCLUSION

The present study found that there is increase in respiratory muscle strength with increase in waist circumference whereas there is no association found between BMI and respiratory muscle strength.

The findings of the study suggest that the respiratory muscle strength is more in individuals with higher waist circumference values whereas with BMI it is inconclusive.

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Institutional Ethics Committee

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