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RESEARCH ARTICLE

A comparative study on the effect of increased body mass index on pulmonary function and respiratory muscle strength in young adults

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ABSTRACT

Background: Obesity decreases the working ability of the persons and leads to a number of morbid conditions. Respiratory muscle strength assessment in obese individual helps to understand the modifications that the body does in turn to the ever-increasing oxygen intake and carbon dioxide output. **Aim and Objectives:** The aim and objective of this study is to determine the association between the increasing body mass index and the respiratory muscle strength in young adults using spirometry and estimation of the maximum inspiratory and maximum expiratory pressures. **Materials and Methods:** The Institutional Ethics Committee clearance was obtained and written informed consent form was obtained from all the research participants. Age-matched obese (n = 32) and non-obese (n = 32) individuals were recruited, and their anthropometric data were recorded. Spirometry was done using RMS Helios 407 PC Based Spirometer. Maximum inspiratory and expiratory pressures were measured using a custom-built standardized equipment. The American Thoracic Society/European Respiratory Society guidelines were followed in the conduct and calibration of the machines used. Pearson's correlation and student t-test were done for the parameters of interest using GraphPad Prism v5.0 software for statistical analysis. Significance was set at $P < 0.05$. **Results:** A significant change in the parameters such as maximum voluntary ventilation and maneuver tidal volume was found. Non-significant changes in other spirometry parameters were seen between the obese and the non-obese individuals. **Conclusion:** Our results were in contradictory to those findings wherein there was a decrement in the spirometric and respiratory muscle strengths; however, there was also literature that is concurrent to our findings. The significant increase in the respiratory muscle strength in obese individuals might be a compensatory effect to the exertion to be done against the increased lung function required in obese individuals with an equivalent effort to that of non-obese normal individuals.

KEY WORDS: Obesity; Respiratory Muscle Strength; Forced Vital Capacity

INTRODUCTION

Obesity is a complex multifactorial disease that leads to numerous adverse health conditions.[1] Global statistics on obesity in the year 2013 reports the proportion among adults with body mass index (BMI) >25 kgm^2 as adult men (36.9%) and women (38.0%). Published literature sources from most of the developing countries also report a rise in the childhood and adolescent obesity[2] The National Family Health Survey (NFHS)-3 reports a rise in the percentage of obesity of ever-married women aged 15–49 years from 11% (NFHS-2: 1998–1999) to 15% (NFHS-3: 2005–2006).[3] School surveys in Indian cities indicate a rising trend in the prevalence of childhood and adolescent obesity.[4]

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Obesity in young adults decreases their working ability and could lead them to numerous morbid conditions as soon as they reach their adulthood. Assessment and comparison studies on respiratory muscle strength in obese young adults are less. An obese individual's metabolic demands are high which are reflected in their oxygen intake and carbon dioxide output than the normal persons both at rest and in exercise.[5] This imposes an additional physiological burden with an increase in the work of breathing which is directly reflected in the strength of the respiratory muscles. Obesity is a proven risk factor to many diseases including pulmonary dysfunction and respiratory failure. Respiratory muscle strength assessed through maximum respiratory pressures in obese population is found to have conflicting results, as shown in some to have lower values and in others its high.[6] With very less literature in this area of research, we compared the respiratory muscle strength and lung function between the normal and the obese young adults which might further add on to the existing evidence. Here, in this study, we determined the lung function by spirometry for the selected subjects, along with their respiratory muscle strength to correlate with the obesity they suffer from.

MATERIALS AND METHODS

The Institutional Ethics Committee (Human Studies) approval was obtained before the start of the study. This was an observational study conducted for 2 months. This study included 64 voluntary participants of both sexes between 18 and 24 years of age within our medical college campus. Convenient sampling was done to recruit 32 non-obese (BMI ≥18.0–24.9 kg/m^2) and 32 obese (BMI ≥25 kg/m^2) subjects.[7] Sample size was calculated from an earlier published study[8] using the nMaster v2.0 software with the desired confidence interval of 95%. Subjects of both the genders between the age limits of 18–24 (normotensives only) were included in the study. Persons with the habit of any kind of tobacco use/under medication for any illness/having a habit of regular exercise or yoga were excluded from the study.

Identified research participants visited the Research Laboratory, Department of Physiology Medicine, between 8.00 and 9.00 am with no intake of any caffeinated or carbonated drinks for at least 3 h before the experiment. Complete procedures involved in the study were explained to them in the vernacular language, and the assurance of confidentiality of the data collected was given. Written informed consent was obtained. After a brief introduction about the scope of our study, information on habit of exercise, subjective record of any illness/medication, tobacco use, and alcoholism was collected. Anthropometric data of the subject such as age, sex, height to the nearest centimeter using a wall mount stadiometer, (Easycare R), and body weight (to the nearest kilograms, KRUPS Weighing Machine) were recorded. BMI was calculated using Quetelet's index. After supine resting for 10 min, baseline blood pressure and heart rate were measured using an automatic digital sphygmomanometer (Omron). Three readings were taken with an interval of 1 min and the average was considered for the study. Spirometric tests were done in standing posture using RMS Helios 407 a PC-based Digital Spirometer. Tests such as forced vital capacity (FVC) and maximum voluntary ventilation (MVV) were done. Acceptability and reproducibility of the graphs, flow volume, and flow time were assessed well before considering it as a sample. Maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were measured using the custom-built standardized apparatus which is simple and accurate.[9] Three measurements were performed for both MEP and MIP with the subjects standing up and the highest value was taken into account. MEP was measured from total lung capacity, after a maximum inspiration and MIP from residual volume after a maximum expiration as per the American Thoracic Society/ European Respiratory Society guidelines.[10] Collected data were entered into Microsoft Excel file and stored in computers for later analysis.

Pearson's correlation was done for finding the association between the BMI and respiratory muscle strength, and student *t*-test was done to estimate the statistical significance obtained between various parameters between the obese and non-obese groups of research participants. All statistical analyses were performed using GraphPad Prism v 5.0 software, with statistical significance set at $P < 0.05$.

Ethical Consideration

This study was approved by the Institutional Ethics Committee of Shri Sathya Sai Medical College and Research Institute, Ammapettai, Kancheepuram, Tamil Nadu.

RESULTS

The study results are tabulated here [Table 1] with the statistically significant changes accepted with $P < 0.05$. Demographic details between the two groups showed non-significant characteristics in the age and height criteria; however, there was a significant change in the weight and BMI as calculated through the Quetelet's index.

Those parameters of interest in the control and obese with respect to the spirometric changes in obese individuals when compared with the control (non-obese) participants are listed in Table 2.

Table 1: Anthropometric data between the obese and non-obese participants

Variables	Obese (*n*=32) Mean±SD	Non-obese (*n*=32) Mean±SD	*P* value
Age (years)	20.13±1.035	20.29±0.99	0.57
Height (cm)	164.50±1.78	166.7±1.45	0.35
Weight(kg)	54.67±1.96	80.29±2.08	0.0001*
BMI(kg/m^2)	20.61±0.43	28.89±0.62	0.0001*

*statistically significant, SD: Standard deviation

Table 2: Comparative data on the different respiratory parameters in the study participants

Parameters	Control (Mean±SD)	Obese (Mean±SD)	*P* value
FEV_1 (L)	2.50±0.14	2.77±0.09	0.13
FVC (L)	2.58±0.14	2.87±0.10	0.12
FEV_1/FVC	96.70±0.83	96.63±1.10	0.95
MEP (mmHg)	46.13±3.26	44.90±2.88	0.78
MIP (mmHg)	42.29±3.16	49.00±5.16	0.25
MVV (L)	100.10±5.07	116.70±5.88	0.03*
MRf (Per min)	99.05±4.26	98.14±8.10	0.91
MVT (L)	1.041±0.06	1.348±0.09	0.01*

*statistically significant, SD: Standard deviation, FEV_1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, MEP: Maximum expiratory pressure, MIP: Maximum inspiratory pressure, MVV: Maximum voluntary ventilation, MVT: Manoeuver tidal volume

We found that there were no significant changes in the forced expiratory volume in 1 s (FEV_1), FVC, and the FEV_1/FVC values. Parameters such as MEP and MIP which are the indirect measure of the inspiratory and expiratory muscle strength showed no significant changes among the groups. However, another two parameters such as the MVV and manoeuver tidal volume (MVT) values showed significant changes with the higher values in the obese individuals than in the control non-obese participants.

Association between the respiratory muscle strength parameters against BMI is studied in Table 3, and the results were found to show only the MVV and MVT parameters showing significant positive correlation results.

Table 3: Association between BMI and the other respiratory muscle strength parameters

Parameters	Pearsons correlation coefficient	*P* value
BMI×MEP	−0.07	0.686
BMI×MIP	0.08	0.602
BMI×MVV	0.45	0.005*
BMI×MVT	0.38	0.021*

*Statistically significant, BMI: Body mass index, MEP: Maximum expiratory pressure, MIP: Maximum inspiratory pressure, MVV: Maximum voluntary ventilation, MVT: Manoeuver tidal volume

DISCUSSION

Obesity a common yet controllable risk factor for most of the disorders that the new generation is experiencing these days across the globe has gained such importance due to the ever increasing morbidity and mortality due to the diseases it brings it into a person.

Obesity and Spirometric Parameters FEV_1, FVC, and FEV_1/FVC

Spirometric estimation of the above parameters in the selected obese and non-obese persons was found to be non-significant. Our study was concurrent with the findings of Devishetty *et al*.[11] who stated that there were non-significant changes in the spirometric parameters between the obese and non-obese individuals. In one another similar study by Al Ghobain, the finding was similar with no significant changes in the lung parameters between obese and non-obese.[12]

In contrast to our findings as described by other researchers, there was a decrease in the above-said parameters and they suggest that it may be due to a decrease in the total respiratory system compliance.[13] The reduction in these spirometric values is also reported in the studies done by Naimark and Cherniack[14] The suggested reason for the non-significant changes in the decreased chest wall compliance is the accumulated fat in the chest around the ribs, abdomen, and the diaphragm.[15] Our study was in contradiction with the study of Sahebjami and Gartside[16] who had reported a decrease in these spirometric parameters along with the decrease in the MVV. They have also suggested as reason the restriction rather than the obstruction to the airflow.

Obesity and Respiratory Muscle Strength Parameters

MVV is a global method unspecific to evaluate respiratory function and respiratory muscle resistance.[17] Our study results showed a marginal yet statistically significant increase in the MVV and MVT values, indicating that these muscles are involved in working more in the overload situation in the obese and hence gaining more strength.[18] Our study results with increased respiratory muscle strength were concurrent with one another study done by Pazzianotto-Forti[19] wherein they reason out it to be differences in the methodology adopted in the estimation of respiratory muscle strength. Non-significant increment in the MIP might be attributed to the increased work done by the inspiratory muscles against the fat deposited in the chest in obese individuals.[6] Obesity is said to affect the respiratory muscle strength but in a positive way to enhance its strength due to the fat deposition in the chest that requires more force for ventilation mechanics. This resistance and the work done against the accumulated fat adapts the respiratory muscles against the pressure needed for respiration leading to gain of more strength.[20]

Association between the Increasing BMI and the Respiratory Muscle Strength Parameters

The association between BMI and the respiratory muscle strength depends on the extent and type of obesity. Our study showed a negative non-significant correlation between MEP and BMI which was similar to that of those studies reported by Weiner *et al*.[21] and Da Rosa *et al*.[22] However, our study results showed a statistically significant positive correlation between the respiratory muscle strength parameters such as MIP, MVV, MVT against the increasing BMI which are concurrent with the reports of Abdalla et al.,[23] Harik-Khan *et al*.,[24] Leech *et al*.,[25] and Carpenter *et al*.[26] The reason for this was found to be an increase in the size and shape of the respiratory muscles that is seen with an increase in the body weight and thereby the strength in these muscles.[27] A higher proportion of skeletal muscle mass and type II fibers was also reported as evidence for the increased respiratory muscle strength gained as a result of increased daily physical effort to do movements against the loaded chest in obese individuals.

Limitations of the Study

The study had a calculated sample to understand the differences among the selected two groups from a single center only, and the instrument though calibrated to the precision was a custom-built machine only.

CONCLUSION

The significant increase in the respiratory muscle strength in obese individuals might be a compensatory effect to the exertion to be done against the increased lung function required in obese individuals with an equivalent effort to that of non-obese normal individuals. However, this may be fall with the bodyweight crossing a limit to perform with the respiratory requirements of the body landing up in morbidities.

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