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RESEARCH ARTICLE

CORRELATION STUDY OF ADIPOSITY MARKERS AND ABDOMINAL STRENGTH WITH PULMONARY FUNCTIONS IN INDIAN ADULT POPULATION

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ABSTRACT

Introduction: In obese people presence of adipose tissue around the rib cage, abdomen and in the visceral cavity loads the chest wall and reduces chest wall expansion which in turn reduces the pulmonary functions. In obesity, abdominal muscle strength is also decreased which in turn affects pulmonary functions. So the present study was conducted to investigate whether there is correlation between various adiposity markers like Body mass index, waist circumference, waist to hip ratio and abdominal strength with pulmonary function parameters like, FVC, FEV1 and MVV.

Methods and Materials: The Present study was conducted on 80obese and non- obese subjects of both the sex between 30 to 55years of age. The parameters studied were anthropometry measurements (height, weight, BMI), adiposity markers (waist circumference, hip circumference, waist to hip ratio) and abdominal strength with Pulmonary functions.

Results: There was statistically significant reduced pulmonary functions among the obese (BMI-28.99±3.34kg/m2)subjects compared to non-obese (BMI -22.81±3.48kg/m2) subjects. Among the adiposity markers BMI shows negative correlation with pulmonary parameters like FVC, FEV1and MVV. While waist circumference, waist hip ratio did not show any correlation with PFT parameters and abdominal muscle strength shows positive correlation with PFT parameters.

Conclusion: It is well recognized that obesity affects the mechanics and physiology of the respiratory system. The result suggests that BMI is an important and better predictor of pulmonary function than abdominal adiposity markers. Poor abdominal muscle strength affects pulmonary functions adversely.

INTRODUCTION

Obesity is a health hazard characterized by an excessive accumulation of fat that causes a generalized increase in body mass. It has become an important health problem in developing countries particularly in India. It has been linked to numerous metabolic complication likedyslipidaemia, type-2 diabetes mellitus, and cardiovascular complications like hypertension, coronary heart disease (CHD), stroke, and certain cancers (Sowers, 2003; Guilleminault *et al.,* 1981). It has also been reported to be negatively associated with pulmonary functions like dynamic lung volumes including forced vital capacity (FVC) and forced expiratory volume (FEV) . Pattern of obesity especially central i.e abdominal obesity is an important predictor of altered lung functions. There are various adiposity markers such as BMI, waist circumference and waist to hip ratio to assess obesity related disorders. Body mass index (BMI) which is a reflection of weight and height is calculated as the weight in kilograms divided by the square of the height in meters (BMI = weight (kg)/height (m2)).

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The world Health Organization (WHO) classified obesity using BMI cut-off values of 25 and 30 kg/m2. BMI of 25.0-29.9 kg/m2 is considered overweight and a BMI of 30 kg/m2 or higher is considered obese (Guilleminault *et al.,* 1981). Waist circumference more 90 cm in male and more 80 cm in women considered as abdominal obesity. BMI illustrate the best estimate of total body fat while waist circumference gives an estimate of visceral fat and risk of obesity related diseases. The validity of BMI in predicting body fat is well-established in different age, gender and racial groups. Abdominal obesity usually results in reduction in compliance of respiratory system leading to decrease in lung volumes resulting mostly in a restrictive and obstructive type of ventilatory defect. Compression of thoracic cage by excessive fat accumulation on abdomen and increased pooling of blood in pulmonary vasculature mainly contribute towards reduction in respiratory compliance.

Abdominal obesity has also been proposed as an overall indicator of mortality and morbidity (Strachan, 2004).In most epidemiologic studies, waist circumference (WC) and waist to hip ratio (WHR) represent abdominal adiposity, however in our study we included abdominal strength as a marker of abdominal adiposity (Raison *et al.,* 2001; Chen *et al.,* 1993).

Abdominal muscle weakness also enhances development of alteration in pulmonary functions. Previous studies have shown positive the correlations between abdominal muscle strength and pulmonary functions. Obesity has also been associated with abdominal muscle weakness. Since obesity is always associated with various alterations of pulmonary origin, it becomes necessary to assess the pulmonary function in obese to identify and treat these alterations at an early stage in order to prevent negative effects on health and quality of life. We hypothesized that greater accumulation of abdominal fat is associated with lower levels of FEV1,FVC and MVV and decreased strength of abdominal muscles and that abdominal obesity is a better predictor of reduced pulmonary functions.
Therefore, the present study was designed to co-relate the adiposity markers and abdominal strength with pulmonary functions of obese and non obese subjects.

METHODS AND MATERIALS

Study group was consisted of 40 obese subjects randomly selected from the employees of BJGMC and Sassoon Hospital and general population Pune compared with 40 age and sex matched control group. Considering the objective of the study the selection was done observing the following inclusion criteria 1) Age between 30-55yrs 2) physically and mentally fit 3) co-operative and capable of understanding procedure 4)Not suffering from any respiratory or cardiac disease and abdominal diseases. The volunteers were asked to avoid tea, coffee and other stimulants to report with light breakfast at department of physiology, BJGMC Pune, in the forenoon to avoid diurnal variation. They were familiarized with procedure and demonstration of tests was done to help them to get adopted with procedure. Approval of ethical committee and due consent of volunteers was taken local ethical committee, BJGMC Pune.

Study Protocol

The study was conducted in Physiology department, BJGMC, Pune. Following parameters were measured.

Anthropometry

- Age-was recorded from birthday by calendar to the nearest of year
- <6mthsand>6mths
- Standing height- was recorded without shoes and with light cloths on a wall
- mounted measuring tape to nearest to centimeters (<5mm and>5mm)
- Weight-- was recorded without shoes and with light cloths on balance scale
- Body mass index (BMI) was calculated by formula of weight (in kg) and
- height(inmeters) 2
- Waist circumference (WC):- WC was measurement with light cloths with feet 25-30cm apart and weight equally balanced with tailors measuring tape in a plane perpendicular to long body axis at the level of umbilicus without compression of skin with nearest to 0.1cm.WC >90cm in men and>80cm in women were defined as abdominal obesity using WHO guidelines
- Hip circumference (HC) measurement done with minimal, adequate clothing across the greater trochanter with legs and feet together by measuring tape without compressing the skin fold
- Waist to hip ratio: -measured from the ratio of WC and HC and is measure of central pattern of fat distribution(>0.9 for male and>0.8 for female)

Respiratory parameters: pulmonary function tests were measured by using RMS-HELIOS-702 machine. The subjects were demonstrated the FVC maneuver in spirometry after they were allowed to rest for 5-10 min and after educating them about the technique the test was carried in a sitting position and the subject was asked to close the nose. The flow volume timed graphs were taken out in accordance to the criteria based on the American Thoracic Society (Carey *et al.,* 1999) and best of the three acceptable curves was selected

The following spirometeric parameters were recorded

FVC : Forced Vital capacity (L/sec)
FEV1 : Forced expiratory volume in 1^{st} sec
MVV: Maximum voluntary ventilation(L/min)

The Forced Vital Capacity (FVC) manoeuvre was conducted in the following order:

- Subjects were instructed to take slow and deep inspiration.
- Then subjects were instructed to hold the mouthpiece in the mouth with lips pursed around it and asked to blow forcefully into the mouthpiece as long as possible without hesitation and coughing. Then without removing the mouthpiece from the mouth, they were instructed to inspire maximally through the mouthpiece.

Parameters recorded in this manoeuvre are

- Forced vital capacity (FVC) in litres.
- Force expiratory volume in one second (FEV_1) in litres.

MVV: Maximum voluntary ventilation(L/min)-
For calculating MVV subject was instructed to breathe as deeply and as rapidly as he can for 15 sec.

Abdominal strength was measured as follows

Grades 5: normal - supine position with hands clasped behind head person should be able to complete range until inferior angle sof scapulae are off the table.
Grade 4: good – same supine positionarms crossed over the chest, person should be able to complete range until inferior angle sof scapulae are off the table.
Grade 3: fair – same supine position with arms outstretches in full extension above plane of body, person should be able to complete range until inferior angle sof scapulae are off the table.
Grade 2: poor – supine position with arms at sides, knee flexed, person should be able to lift head of the table/ depresion of rib cage on cough
Grade 1: trace – supine position with arms at sides, knee flexed, assisted neck flexion/ depresion of rib cage with palpable muscle contraction / unable to cough but papable abdominal muscle activity.

Grade 0: flaccid- supine position with arms at sides, knee flexed, no muscle contraction palpable.

The results for each parameter were compared between the obese and non obese groups and statistically analyzed.

Statistical analysis

Statistical analysis was done by Student's unpaired' t"test.

Correlation of adiposity markers and abdominal strength with PFT parameters was done by Pearson correlation coefficient test.

RESULTS

Table I illustrates the anthropomorphic parameters in obese and non obese subjects showing no significant differences (p> 0.05)between obese and non obese subjects when age and height were compared suggesting that the population studied is homogenous in nature. As expected the weight and adiposity parameters like BMI (28.99+3.34),WC (109.3+6.17) and WHR(1.04+0.04) were significantly (p<0.0001) higher in obese groups compared to control BMI(22.81+3.48kg/m2), WC (81.83+6.9) and WHR(0.96+0.02)

Table 1. Comparison of anthropometric measurement in obese and non-obese group

Parameter	Obese (n=40)		Non obese (n=40)		Z Value	P Value
	Mean	SD	Mean	SD		
Age (Yrs)	45.83	5.81	44.1	5.49	1.37	>0.05
Height(cm)	161.65	6.5	162.23	6.82	1.47	>0.05
weight(kg)	74.69	7.67	59.74	5.99	6.11	<0.0001
BMI	28.99	3.34	22.81	3.48	8.1	<0.0001
Waist ratio	109.3	6.17	81.83	6.9	18.77	<0.0001
Hip ratio	104.2	5.67	85.2	7.33	12.97	<0.0001
WHR	1.04	0.04	0.96	0.02	11.31	<0.0001

Table 2. Comparison of FVC, FEV1 and MVV in Obese and Non obese group

Parameter	Obese (n=40)		Non obese (n=40)		Z Value	P Value
	Mean	SD	Mean	SD		
FVC	2.05	0.44	2.91	0.59	7.39	<0.0001
FEV1	1.82	0.53	2.67	0.62	6.59	<0.0001
MVV	56.43	12.66	79.71	13.45	7.97	<0.0001

Table II shows there was significantly significant (P<0.0001) lower FVC (2.05+0.44), FEV1(1.83+0.53) and MVV (56.43+12.16) in obese as compared to non obese FVC (2.91+0.59),FEV1(2.67+0.62),MVV(79.71+13.45).

Table 3. Correlation between BMI and PFT parameters in Obese and non obese group

Correlation between	Obese		Non obese	
	r Value	P Value	r Value	P Value
BMI & FVC	0.49	<0.001	-0.54	<0.0001
BMI & FEV1	0.36	<0.05	-0.54	<0.0001
BMI & MVV	0.44	<0.005	0.19	>0.05

Table III shows positive Pearson co-relation between BMI and PFT parameters in obese BMI with FVC (0.49),FEV1(0.36),MVV(0.44) which indicate as there is increased in BMI, there is further increased respiratory obstruction.

Table 2. Correlation between Waist circumference and PFT parameters in Obese and non obese group

Correlation between	Obese		Non obese	
	r Value	P Value	r Value	P Value
WC & FVC	-0.21	>0.05	-0.10	>0.05
WC & FEV1	-0.23	>0.05	-0.09	>0.05
WC & MVV	-0.30	>0.05	-0.16	>0.05

Table 3. Correlation between WHR and PFT parameters in Obese and non-obese group

Correlation between	Obese		Non obese	
	r Value	P Value	r Value	P Value
WHR & FVC	-0.23	>0.05	0.08	>0.05
WHR & FEV1	-0.07	>0.05	0.17	>0.05
WHR & MVV	-0.15	>0.05	-0.07	>0.05

Table IV shows negative co-relation between WC and PFT parameters in obese WC with FVC (-0.21), with FEV1 (-0.23)and with MVV(-0.30) which is not significant (p>0.05)

Table V shows negative co-relation between WHRand PFT parameters in obese WC with FVC (-0.21), with FEV1(-0.23) andwith MVV(-0.30) which is non-significant (p>0.05)

TABLE VI shows negative co-relation between WHR and PFT parameters in obese WHR with FVC (-0.23),FEV1(-0.07),MVV(-0.15) which is not significant (p>0.05)

DISCUSSION

We investigated the relation of a number of adiposity markers like BMI, waist circumference and waist to hip ratio and abdominal muscle strength with pulmonary functions tests parameters like FVC,FEV1 and MVV in Indian obese (BMI 28.99+-3.34)and non obese (22.81+-3.48) adults. One of the significant finding regarding changes in ventilation caused by obesity was reduction in FVC , FEV1 and MVV(p<0.0001) in obese. Forced vital capacity and forced expiratory volume and maximum ventilator volume are the dynamic lung function tests which indicate obstructive and restrictive pathology.

It appears that obesity can cause various deleterious effects to respiratory functions, such as alterations in respiratory mechanics, decrease in respiratory muscle strength and endurance, decrease in pulmonary gas exchange, lower control of breathing and limitations in pulmonary function tests and exercise capacity (Sowers, 2003; Guilleminault *et al.,* 1981; Lopata and Onal, 1982; Shaheen, 1999). These changes in lung function are caused by extra adipose tissue in the chest wall and abdominal cavity, compressing the thoracic cage, diaphragm and lungs. The consequences are a decrease in diaphragm displacement, decrease in lung and chest wall compliance resulting in a decrease in lung volumes and overload of inspiratory muscles (Guilleminault *et al.,* 1981). MVV test evaluate the respiratory endurance and is influenced by respiratory muscle strength, lung and chest compliance and control of breathing and airway resistance. In case of obese individual, this variable is reduced mainly by mechanical injury to the respiratory muscle caused by excessive weight on the thoracic cavity. Obesity also has a clear potential to have a direct effect on respiratory well-being, since it increases oxygen consumption and carbon dioxide production while at the same time it stiffens respiratory system and increases the mechanical work needed for breathing.

Besides detrimental mechanical factors, obesity induced higher concentration of circulating interleukinand cytokines are also responsible for all these obstructive changes (Guilleminault *et al.,* 1981; Lopata and Onal, 1982; Shaheen, 1999; Tantisira and Weiss, 2001). Obesity is a pro inflammatory condition, hence can contribute to airway hype responsiveness. Visceral adipose tissue influences circulating concentration of interleukin and cytokines that may act via systemic inflammation to affect pulmonary functions. Inflammation may be part of the link between impaired pulmonary function and mortality (Krzyzanowski and Wysocki, 1986; Schunemann *et al.,* 2000; Strachan, 2004; Kannel *et al.,* 1983).

Another important finding of the study is positive correlation of airway obstruction parameters with increasing BMI (P<0.001) in obese as compared to non-obese adults.

Waist circumference and waist to hip ratio did not show significant correlation with pulmonary parameters. Previous study done by Heather M *et al* had found that abdominal obesity is a better predictor of pulmonary function than weight or BMI (Hole *et al.,* 1996). Another study done by Ian Janssen *et al* [11]Suggested that waist circumference and not BMI explains obesity related health risk. The association of pulmonary function and overall weight is a complex issue. It appears that overall obesity can also contribute to drastic changes in pulmonary function by above mentioned mechanism.

Uniqueness of the present study is comparison of abdominal strength with adiposity parameters and pulmonary function test parameters. To the best of our knowledge, this is the first Indian study on association of abdominal strength with pulmonary function test parameters . Important finding of this correlation is positive correlation of abdominal strength with pulmonary function test parameters. Subjects with good abdominal strength with normal BMI have normal pulmonary functions as to those with poor abdominal strength with high BMI. It indicates that obese subjects have poor abdominal muscle strength which contributes to poor pulmonary functions. Abdominal muscles are accessory muscles responsible for inspiration as well as expiration during force ventilation. It is believed that when the ventilator capacities of the lung is compromised, the respiratory functions are affected and individual utilize abdominal muscles to effect forced expiration, thus getting room for improved inspiration action. When abdominal muscles are weak it affects diaphragm movement, vital capacity, lung compliance. Abdominal muscles also play role in effective coughing. Individual with weak abdominal muscles showed ineffective coughing which in turn leads to accumulation of secretions and infection thereby affecting pulmonary functions. Therefore poor abdominal muscle strength associated with high BMI is also one of the important factors responsible for poor pulmonary functions (Ray *et al.,* 1983; Lazarus *et al.,* 1998; Collins *et al.,* 1995).

Conclusion

- Obesity is a risk factor and associated with decrease pulmonary functions.
- There is positive correlation of BMI with lung function parameters
- like FVC, FEV1 and MVV
- Waist circumference, waist to hip ratio did not show any correlation
- With lung function parameters.
- It is overall body weight but not the abdominal fat responsible for
- Decrease pulmonary functions.
- Good pulmonary function can be maintained by good abdominal function
- Muscle strength.

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