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A Study on Effect of Body Mass Index on Pulmonary Function Tests

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Abstract:
Context: Obesity has reached epidemic proportions in India in the 21st Century, with morbid obesity affecting 5% of the country's population.Overweight and obesity are also known to affect the respiratory function in various forms depending on severity.Aim:*To study the effect of body mass index on pulmonary function tests among healthy non-smoking adults of urban area of Kurnool.* ***Settings and Design:****It is a community based observational study conducted at Kurnool Medical College, Kurnool, during the period from August 2015 to July 2016.* ***Methodology:****A total of 120 subjects belonging to the urban area of Kurnool age ranging from 20 to 45 years.The study population was grouped intoGroup A: 40 subjects of Normal Weight with BMI between18.5 to 24.9 Kg/m^2, Group B: 40 subjects of Overweight with BMI between 25 to 29.9Kg/m^2, Group C: 40 subjects who are Obese with BMI ≥30 Kg/m^{2}and student t test (unpaired) performed, and p values generated using IBM SPSS software.* ***Results:****The pulmonary function tests were assessed in terms of Forced Vital Capacity in litres (FVC),Forced Expiratory Volume in 1st Second (FEV_1),FEV_1/FVCRatio, Peak Expiratory Flow Rate in litres/min(PEFR) and Forced Expiratory Flow at 25-75% of FVC($FEF_{25-75\ \%}$).The results were compared and analysed between these three groups of normal weight (Group A),overweight (Group B) and obese subjects (Group C).The mean value of FVC(litres) in Group A is 2.68(actual),3.34(predicted),in Group B, FVC(litres) is 2.48(actual), 3.15(predicted),in Group C, FVC(litres) is 2.09 (actual),2.80(predicted). The FVC value decreased linearly with BMI, as p value was significant when Group A compared with Group C,p valueis 0.00001 (significant), Group B compared to Group C,pvalue0.01 (significant). Themean value of FEV_1(litres) inGroup A is 2.42(actual) and 2.91(predicted), In Group B FEV_1(litres) is2.32 (actual) and 2.76(predicted), in Group C FEV_1(litres)1.95 (Actual) and2.37 (predicted). The FEV_1 value decreased linearly with BMI, as p value was significant when Group A normal weight subjects compared to obese group,pvalue is 0.0003 (significant) and Group B overweight subjects compared with Group C obese group pvalue is 0.01 (significant).The value of FEV_1/FVCRatio(litres)in Group A is 88.95(actual) and86.09(predicted), in Group B FEV_1/FVCRatio(litres)is 89.37(actual) and 85.80 (predicted), in Group C FEV_1/FVCRatio(litres)is 86.16(actual) and 83.76(predicted). The FEV_1/FVC ratio is preserved (no statistical significance is observed) in all the three study groups.The value of PEFR (L/sec) in Group A is 7.05(actual)and 8.65(predicted), in Group B, PEFR (litres/sec) is 6.35 (actual) and 7.91(predicted), in Group C PEFR (litres/sec) is 5.04(actual) and 7.10(predicted).The PEFR (litres/sec) is significantly reduced in Group Boverweight, and Group C obese subjects compared to Group A normal subjects, pvalue 0.00001 (significant)when normal weight group A and overweight group B compared to obese group C.The value of $FEF_{25-75\ \%}$ (litres/sec) in Group A is 3.37(actual), 3.80(predicted),In Group B, $FEF_{25-75\ \%}$(litres/sec) is 2.96(actual) 3.56 (predicted), in Group C $FEF_{25-75\ \%}$(litres/sec) is 2.67(actual), 3.69(predicted).The $FEF_{25-75\ \%}$ is significantly reduced in Group C Obese subjects compared to Group A Normal weight subjectswith p value is 0.002 (significant).*
Conclusions: *Obesity leads to pulmonary function impairment with all its potential complications. Furthermore, as weight reduction is related to pulmonary function gain in obese subjects, obese persons should be encouraged to lose weight to improve pulmonary function.*

Keywords: Obesity, Body Mass Index (BMI), FVC (litres), FEV_1(litres), FEV_1/FVC%, PEFR (litres/sec), $FEF_{25-75\%}$

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I. Introduction

Obesity is one of the chronic non-communicable diseases, posing as a global health hazard. It is a problem of the newer world with rapidly changing lifestyles, involving consumption of highly processed and calorie rich foods. Though it is increasing in epidemic proportions, it is one of the most neglected public health problems in the world according to WHO. It was not, until the 20th century that the WHO finally recognized obesity as a global epidemic. A new word describing the global nature of the epidemic has been coined – "globesity".

India has the third highest number of obese and overweight people (11% of adolescents, 20% of all adults) after U.S. and China. Overweight and obesity are associated with an increased burden of diabetes, hypertension, cardiovascular diseases, hyperlipidaemia, stroke, metabolic syndrome, osteoporosis, arthritis, gall bladder diseases and gall stones, some type of cancers, gout, premature deaths, and reduction in overall quality of life. Overweight and obesity are also known to affect the respiratory function in various forms depending on severity. Obesity forms a major cause of dyspnoea, exercise intolerance, functional limitation, and disability.

Obesity is important risk factor for pathophysiological changes contributing to altered lung functions,even if they have no respiratory illness. Both static and dynamic lung volumes are compromised in obesity. Obesity is found to decrease the lung volumes and capacities is by decreasing both lung and chest wall compliance. There is also increase in resistance to outflow of air through the airways in obesity. The pattern of pulmonary function is found to worsen with the degree of obesity moving from a restrictive pattern in mild and moderate obesity with both $FEV_1$and FVC reduced and the ratio being normal to an obstructive pattern in severe and morbid obesity with significant decrease in FEV_1 against FVC and FEV_1/FVC ratio being decreased.

Obese people are at increased risk of respiratory symptoms such as breathlessness, particularly during exercise, even if they have no obvious respiratory illness. Obesity has a clear potential to have a direct effect on respiratory wellbeing. In addition to exertional breathlessness and limited exercise capacity, the changes in pulmonary mechanics due to obesity can impact on patients with concomitant chronic respiratory illness, including asthma and COPD. More importantly, it can result in sleep disordered breathing, including Obstructive Sleep Apnoea (OSA) and Obesity Related Respiratory Failure (ORRF). While the clinical implications of obesity such as diabetes,vascular disease and osteoarthritis are well established, less emphasis is traditionally placed on the effects of obesity on the respiratory system.

To investigate the effect of obesity on the respiratory system, most researchers use values of pulmonary function tests. Because obesity is one of the factors which affects pulmonary function tests, this study helps to identify and treat the changes in the early stage, in order to prevent negative effects on health and quality of life. Therefore, the objective of this study, is by comparing the obese and non-obesesubjects, to evaluate the impact of obesity on the pulmonary functions of subjects with no history of pulmonary disease.

II. Methodology

The present study was conducted in The Department of Physiology, Kurnool Medical College, Kurnoolfrom August 2015 to July 2016.Study populationof total of 120 subjects belonging to the urban area of Kurnool. Subjects belong to the age ranging from 20 to 45 years. The study population was grouped into the following groups depending on BMI (normal weight, overweight and obese groups), Group A: 40 subjects with BMI between18.5 to 24.9 Kg/m^2, Group B:40 subjects with BMI between25 to 29.9 Kg/$m^2$and Group C:40 subjects with BMI $\geq$30 Kg/m^2.

Inclusion criteria: Males & females aged between 20 to 45 years with apparently normal general health were selected. Informed Consent to participate in the present study was taken after explaining about the test procedure.The study was started after obtaining the clearance of the ethical committee. Exclusion criteria:Subjects with known respiratory diseases, with history of any respiratory complaints like cough, shortness of breath or history of upper respiratory tract infection for past 4 weeks, Subjects with cardiovascular diseases, skeletal deformities and endocrine disorders, Subjects with history of tobacco chewing, smoking and alcohol consumption, Pregnant and lactating women, Anxious, apprehensiveandunco-operative subjects are excluded from our study

The test was carried out in a well ventilated and quiet room with ambient temperature ranging from 28^0 C to 35^0 C. The subjects were asked to avoid beverages like tea, coffee and other stimulants and to report with light breakfast in the forenoon. The subjects were allowed to rest for 5-10 minutes before recording the lung functions and the procedure to be carried out were demonstrated to them. All the subjects underwent a thorough medical history and full physical examination. Anthropometric measurements such as height and weight were measured prior to the test procedure. The age was recorded from birthday in terms of completed years.

The standing height of the subjects was recorded on a wall mounted measuring tape to the nearestcentimetre, Body weight was measured using a standardised weighing scale to the nearest 0.1 kilogram with light clothing and without footwear. Body mass index (BMI) was calculated using Quetelet‟s index i.e., a person's weight in Kilograms(Kg)divided by the squared height in meters, BMI = Weight (in kgs)/Height (in m^2),

Body mass index is a simple index of weight for height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in Kilograms divided by the square of the height in meters. It is the simple measureof body size. Body mass index(Quetelet‟s index) =weight(kg)/height(m^2)**,**In the present study, the subjects were divided into three groups based on Body Mass Index, according to WHO recommendation for Asian population intoNormal weightsubjects with BMI between18.5 to 24.9 Kg/m^2 Overweight- subjects with BMI between 25 to 29.9 Kg/m^2 Obese- subjects withBMI ≥30 Kg/m^2

Pulmonary functions were measured with portable PC based spirometer (Spirolab version 4.0,a Windows OS based spirometer) with printeris used for the present study, According to ATS recommendations (1987) spirometry was performed during morning hours in a climate control room, in a clean area. The Spirolab has a mouthpiece attached to a transducer which is connected to the computer by a serial cable. Software was loaded in the instrument. This software allows the calculation of the predicted values of age,gender,weight,height and gives the values of all parameters. **Test procedure:** There are three distinct phases to the FVC manoeuvre as follows: 1) Maximal inspiration 2)A blast of exhalation3)Continued complete exhalation to the end of test. Before the test the subjects were given full physical and mental rest. The subject should inhale rapidly and completely from Functional Residual Capacity (FRC). The breathing tube should be inserted into the subject's mouth making sure that the lips are sealed around the mouth piece and tongue does not occlude it and then the Forced Vital Capacity (FVC) manoeuvre should be started with minimal hesitation. Reduction in Peak Expiratory Flow(PEF) and Forced Expiratory Volume in the first second(FEV_1)have shown when inspiration is minimal. The subject should be prompted to blast, not just blow the air from the lungs and he should be encouraged to fully exhale. Throughout the procedure enthusiastic coaching of the subject using appropriate body language and phrases such as keep going is required. If the patient feels dizzy, the manoeuvre should be stopped immediately as syncope could follow due to prolonged interruption of venous return to the thorax. After the point of full lung inflation, subject should deliver the blow without any delay. Hesitating for as little as 2 seconds or flexing the neck allows the tracheal viscoelastic properties to relax and Peak Expiratory Flow (PEF) to drop by as much as 10%, spitting or coughing at the start of the blow may falsely raise the recorded PEF in some individuals. The test was carried out with the subjects in sitting position and nose clip held in position on the nose. The subjects performed three acceptable manoeuvres according to American thoracic society guidelines. Criteria for a satisfactory effort for recording a forced expiratory spirogram:1)Maximal inhalation before start of test. 2)Satisfactory start of exhalation as shown by i)Evidence of maximal effort. ii)No hesitation during the expiratory effort. iii)No cough or glottal closure during the first second. 3)The effort should last for a minimum of 6 seconds, or a plateau with a change in volume of less than 40 ml for at least 2 seconds towards the end of the effort. 4)No evidence of leak 5)No evidence of obstruction of the mouthpiece6)The Subject was instructed to assume the correct posture with head slightly elevated. 7) Nose clip is kept in position. 8) Instructed to take maximum inspiration. 9) Mouthpiece is kept in the mouth immediately with tight and close approximation of lips around the mouthpiece. 10) Instructed to exhale rapidly, forcibly, and completely like a blast until no more air can be expelled while maintaining the upright position. 11) Instructions were repeated as and when necessary

Once the procedure was satisfactorily performed, the final recording of the pulmonary function tests was obtained and the best of them selected for analysis. Data is organized,analysed and interpreted using the IBM SPSS. Parameters chosen for study are FVC (litres) FEV_1(litres) FEV_1/FVC ratio FEF $_{25\text{-}75\ \%}$ (litres/sec) PEFR (litres/sec),Statistical analysis was done by IBM SPSS software generating Mean values, Standard deviation, Student 't' Test, andProbability value (P-value). P Value of < 0.05 was considered as significant

III.Results

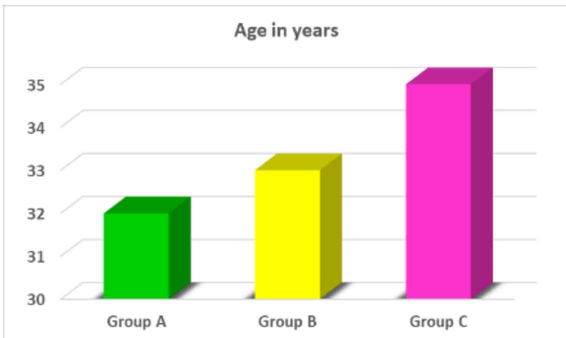

Figure No 1: Age wise distribution of study population

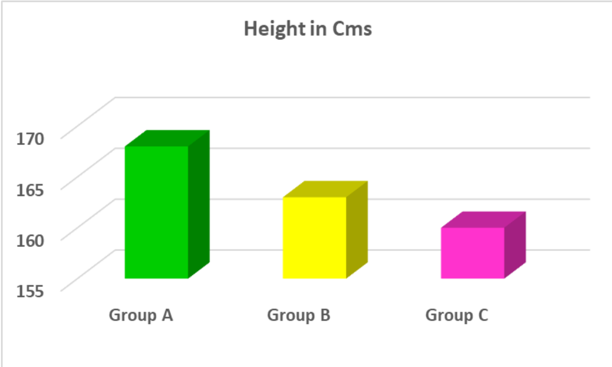

Figure No 2: Height wise distribution of study population

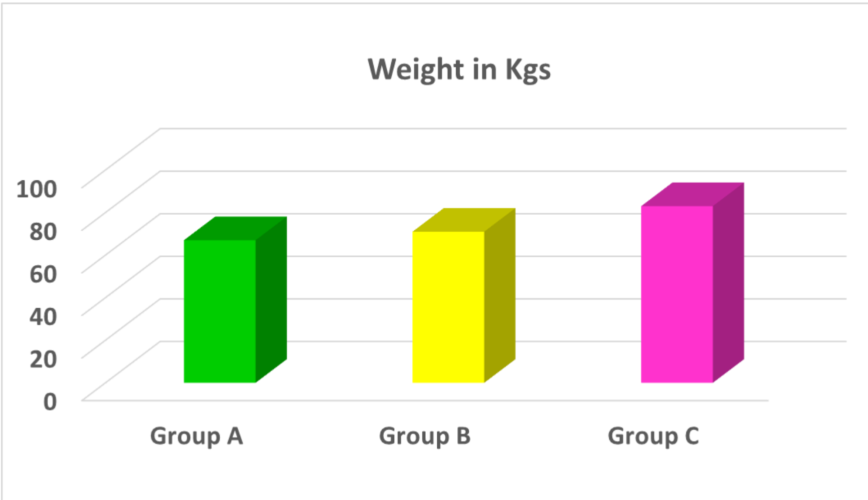

Figure No 3: Weight wise distribution of the study population

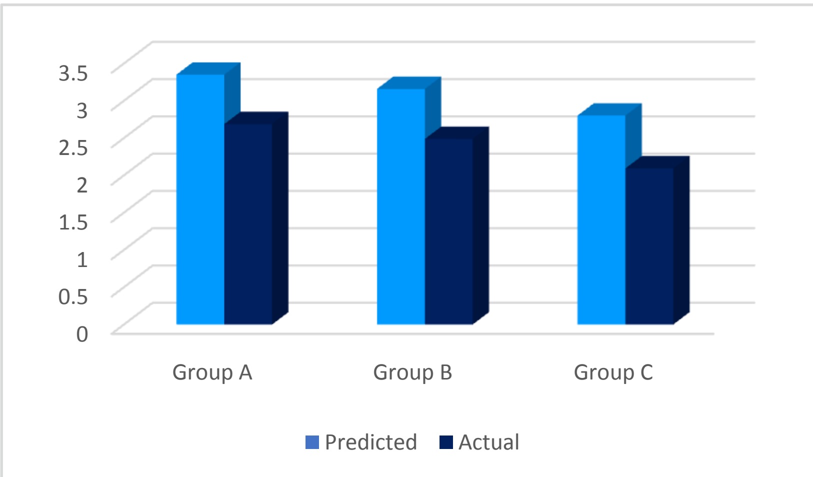

Figure No 4: FVC values in all three study groups

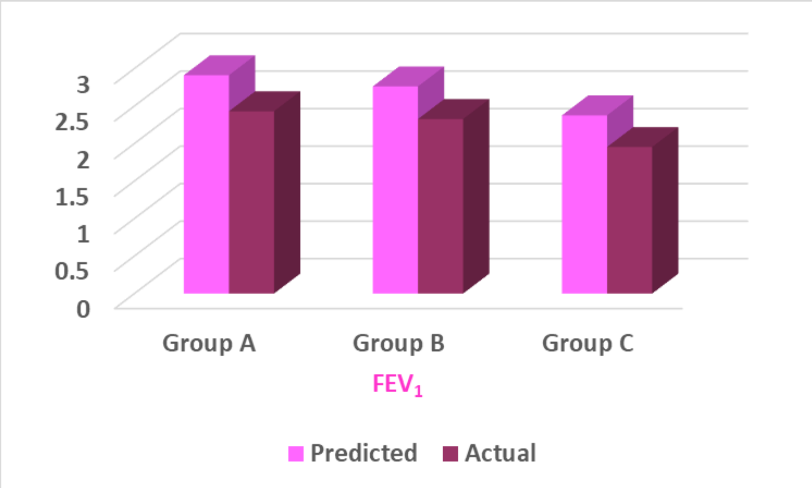

Figure No 5: FEV_1 values of all three study Groups

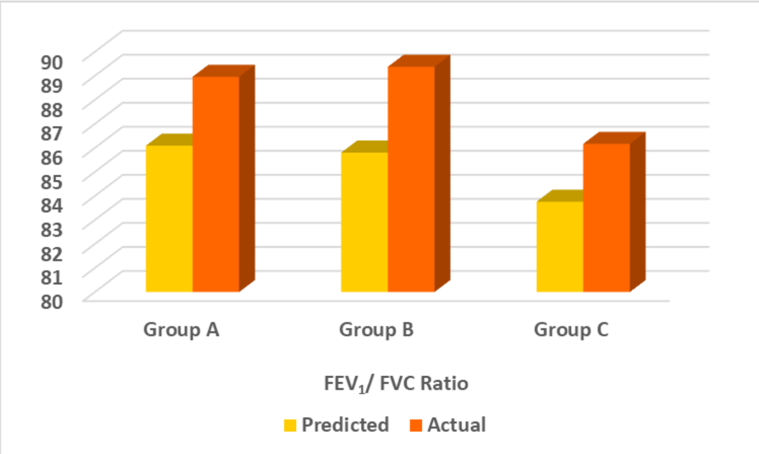

Figure No 6: FEV1/FVC ratio in all the three study groups

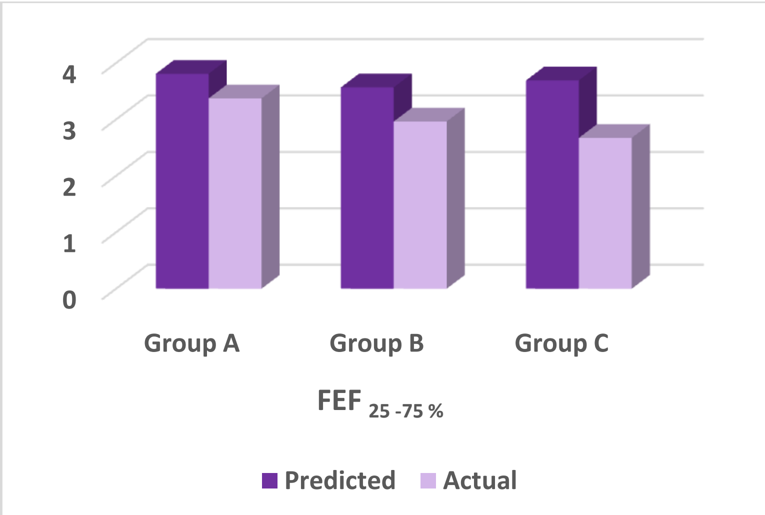

Figure No 7: $FEF_{25-75\%}$in all the three study groups

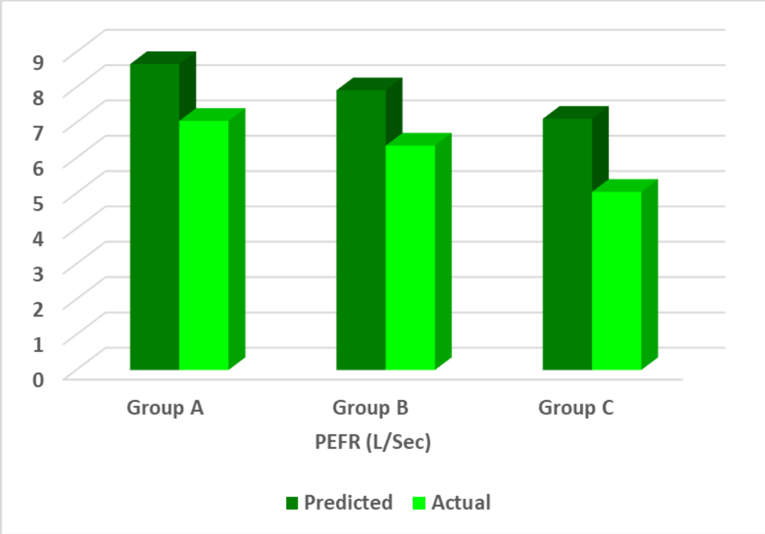

Figure No 8: PEFR (litres/sec) in all the three study groups

Table No 1: Distribution of study population showing different groups

S.No.	Group	Numbers
1	Group A	40
2	Group B	40
3	Group C	40
	Total	**120**

Table No2: The demographic data for all the three groups

S.No.	Parameter	Group A	Group B	Group C
1	Age in years	32	33	35
2	Height in Cms	168	163	160
3	Weight in Kgs	67	71	83

Table No 3: Comparison of FVC values of the three study groups

FVC (liters): Predicted	**Group A**	**Group B**	**Group C**
Mean	3.34975	3.158	2.8015
S.D	0.678068	0.777854	0.793491
Comparison	**Group A and B**	**Group A and C**	**Group B and C**
t value	1.175234	3.322109	2.029137
p value	0.243476 (Not significant)	0.001362 (Significant)	0.045856 (Significant)
FVC (Liters): Actual	**Group A**	**Group B**	**Group C**
Mean	2.68725	2.4875	2.093
S.D	0.598781	0.783806	0.529185
Comparison	**Group A and B**	**Group A and C**	**Group B and C**
t value	1.28081	4.703196	2.638236
p value	0.204056 (Not significant)	0.00001 (Significant)	0.010057 (Significant)

Table No.4:Comparison of FEV_1 values of the three study groups

FEV_1 (Litres) : Predicted	Group A	Group B	Group C
Mean	2.91	2.7615	2.37575
S.D.	0.726724	0.779311	0.63941
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	0.881397	3.490686	2.420207
p value	0.380811 (Not Significant)	0.000796 (Significant)	0.017838 (Significant)
FEV_1 (Litres) : Actual	Group A	Group B	Group C
Mean	2.42975	2.32675	1.9535
S.D.	0.596096	0.772493	0.538343
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	0.667623	3.750047	2.507126
p value	0.506345 (Not Significant)	0.000338 (Significant)	0.01425 (Significant)

Table No 5: Comparisons of FEV_1/FVC values of three study groups

FEV_1/ FVC RATIO : Predicted	**Group A**	**Group B**	**Group C**
Mean	86.093	85.80425	83.761
S.D.	6.674336	6.647336	4.610755
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	0.193869	1.818136	1.597385
p value	0.846783 (Not Significant)	0.072882 (Not Significant)	0.114224 (Not Significant)
FEV_1/ FVC RATIO: Actual	**Group A**	**Group B**	**Group C**
Mean	88.95925	89.3765	86.167
S.D.	11.64684	7.095331	11.23889
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	0.193499	1.091102	1.527224
p value	0.847071 (Not Significant)	0.278587 (Not Significant)	0.130751 (Not Significant)

Table No 6: Comparisons of $FEF_{25-75\%}$ values of three study groups

$FEF_{25-75\%}$ (litres/sec): Predicted	**Group A**	**Group B**	**Group C**
Mean	3.80825	3.5675	3.69075
S.D.	1.034118	0.679633	0.729047
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	1.230456	1.987333	0.782082
p value	0.222224 (Not Significant)	0.045868 (Significant)	0.436534 (Significant)
$FEF_{25\ 75\ \%}$ (litres/sec) : Actual	**Group A and B**	**Group A and C**	**Group B and C**
Mean	3.3725	2.963	2.67275
S.D.	1.032045	0.848952	0.932661
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	1.938042	3.181526	1.455543
p value	0.056237 (Not Significant)	0.002104 (Significant)	0.149532 (Not Significant)

Table No 7: **Comparisons of PEFR values of three study groups**

PEFR (litres/sec): Predicted	**Group A**	**Group B**	**Group C**
Mean	8.6575	7.917	7.10975
S.D.	1.258586	1.688873	1.226731
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	2.22353	5.569655	2.445886
p value	0.029074 (Significant)	0.00001 (Significant)	0.016702 (Significant)
PEFR (L/SEC): Actual	Group A	Group B	Group C
Mean	7.0525	6.351	5.04275
S.D.	1.623315	1.467497	0.838729
Comparison:	**Group A and B**	**Group A and C**	**Group B and C**
t value	2.027444	6.956465	4.895133
p value	0.046033 (Significant)	0.00001 (Significant)	0.00001 (Significant)

IV. Discussion

The study population in each group were equal in numbers. BMI of group A is between 18.5 to 24.9 Kg/m^2. The mean value of age in group A was 32 years, mean height of group A was 168cms, mean weight of group A was 67 kgs. BMI of group B is between 25 to 29.9 Kg/m^2. The mean value of age in group B was 33 years, mean height of group B was 163cms, mean weight of group A was 71 kgs. BMI of group C is ≥30 Kg/m^2. The mean value of age in group C was 35 years, mean height of group C was 160cms, mean weight of group C was 83 kgs.The Mean Values in group A, B & C were showing gradual decrease and p value is highly significant. A significant inverse relationship between Body mass Index and FVC was found in the present study, with increasing significance as BMI increases. Shinde PU,Irani FB, HeenaKousar GH,in their study also observed significant inverse relationship with increasing Body Mass Index and FVC,which is consistent with the present study.Y.chen,S.L.Home,J.A.Dosmanin their studies observed similar findings.

The mean value of FVC(litres) in normal subjects is 2.68725(actual) and 3.34975(predicted),inoverweight subjects the mean value of FVC(litres)is 2.4875(actual) and3.158(predicted),in obese subjects the mean value of FVC(litres) is 2.093 (actual) and2.8015(predicted). The FVC value decreased linearly with BMI, as p value was significant when overweight subjects were compared with obese group (p – value0.010057) and normal weight subjects compared to obese group(p-value0.00001). The value of FEV_1(litres) in normal subjects is 2.42975(actual) and 2.91(predicted), in overweight subjects 2.32675(actual) and 2.7615(predicted), in obese subjects 1.9535 (actual) and 2.37575 (predicted).The FEV_1 value decreased linearly with BMI, as p value was significant when overweight subjects compared with obese group (p – value0.01425)and normal weight subjects compared to obese group(p-value-0.000338). The Mean values in group A, B and C were showing gradual decrease and p value is highly significant in the overweight and obese group compared with normal weight group. A significant inverse relationship between Body Mass Index and FEV_1 was found in the present study, with increasing significance as BMI increases. The present study findings are consistent with the study of AnugyaAparajithaBehra,Basantha Kumar Beghraet.al. who observed that FEV_1 decreases with increasing Body Mass Index.They also found that with one Kilogram increase in weight correlated with a decrease in FEV_1 of approximately 13ml in males and 5ml in females. Anuradha R.Joshi,Rathan Singh and A.R.Joshi in their study also stated that increase in adult body mass is a predictor of FEV_1 decline.

The value of FEV_1/FVC Ratio (litres) in normal subjects is88.95925(actual) and86.093(predicted), in overweight subjects 89.3765 (actual) and 85.80425 (predicted), in obese subjects 86.167 (actual) and 83.761(predicted).The FEV_1/FVC ratio is preserved (no statistical significance is observed) in all the three study groups.No significant relationship between Body mass Index and FEV_1/FVC ratio was observed in the present study. Saulo Maia D Avila Melo,ValdinaloAragao de Melo,et.alalso found no significant differences in FEV_1/FVC ratio with increasing Body Mass Index. Cheryl M.Salome,Gregory G.King,Nobert Berend,in their study observed similar findings.

The value of $FEF_{25-75\%}$(litres/sec) in normal weight subjects is 3.3725(actual) and 3.80825(predicted), in overweight subjects 2.963 (actual) and 3.5765(predicted), in obese subjects 2.67275(actual) and 3.69075(predicted), The $FEF_{25-75\%}$is significantly reduced in obese subjects compared to normal and overweight subjects (p value 0.002104). The Mean values in groups A, B and C were showing significant decrease in the obese group compared to normal weight and overweight group. In the present study, $FEF_{25-75\%}$,which is an indicator of mid-expiratory flow and an early marker of small airway obstruction, which was significantly reduced in obese subjects compared to normal and overweight individuals.

CherylM.Salome,Gregory G.King,Nobert Berend also observed similar findings in their study and stated that the decreasing airflows with an increasing weight, in obese individuals, it is likely to indicate bronchial obstruction, which may be due to persistent remodelling of airways, rather than a direct mechanical effect of airway calibre.
The value of PEFR (litres/sec) in normal weight subjects is 7.0525(actual) and 8.6575(predicted), in overweight subjects 6.351 (actual) and 7.917(predicted), in obese subjects 5.04275(actual) and 7.10975(predicted), The PEFR (litres/sec) is significantly reduced in overweight and obese subjects compared to normal subjects, p value ranging from 0.046033 when normal weight group compared to overweight group to 0.00001when normal weight group and overweight group compared to obese group. The Mean values in groups A, B & C were showing gradual decrease and p value is highly significant. The present study findings are consistent with the study of Shinde PU,Irani FB,Heena Kousar GH,who in their study, also observed a positive correlation with increasing Body mass Index and PEFR. Mohammed Al.Gobain in his study also observed similar findings in his study. The present study is in accordance with the study of Vyoma Joshi,Sweety Shah,who observed a positive correlation between Body mass Index and PEFR.

These findings suggest that with increasing degree of obesity,the pulmonary function pattern is moving from restrictive pattern towards obstructive pattern. As weight reduction and physical activity are effective means of reversing the respiratory complications of obesity, health care policy makers need to develop major strategies to prevent and effectively manage obesity. Also, awareness of the effect of BMI on lung function testing will result in better interpreting the results and hopefully avert unnecessary pulmonary workup. These results will also assist clinicians when interpreting pulmonary function test results in people with normal airway function.

Obesity is a condition that causes damage to the respiratory function. However, studies have demonstrated that weight loss resulted in improvement in lung volumes. It seems that almost all the changes associated with obesity are reversed after significant weight loss and are therefore, likely to be caused by obesity itself. Longitudinal studies of lung function suggest that increased body fatness is predictive of lung function decline and that weight loss can improve both $FEV_1$and FVC. Decreasing body fatness, might, therefore, have clinical implications in terms of improving lung function and reducing the prevalence of sleep disorders such as sleep apnea in overweight and obese individuals. Weight reduction and physical activity are effective means of reversing the respiratory complications of obesity. Weight loss and bariatric surgery among adults clearly showed that reduction of obesity is helpful in improving lung function.After weight loss, FVC and FEV_1 increased respectively, 9.7% and 9.1 % in the morbid obese group and in severe morbid obesity 23.7% and 25.6%. The difference between the two groups, disappeared after weight loss. In moderately obese men, weight loss, improves static lung function,static lung volumes improve with weight loss but not with aerobic exercise in middle aged and older moderately obese, sedentary males. This suggests that weight loss has a positive impact on respiratory function, but not on measures of dynamic pulmonary function in older obese males. This indicates that some of alternations in pulmonary function is attributed to aging are due to obesity and are potentially modifiable in obese men. A few studies have demonstrated that weight loss due to bariatric surgery has resulted in a huge improvement in lung functions with increased FVC and FEV_1, improved alveolar capillary diffusion capacity and improvement in gas exchange. Hence, physicians interpreting lung function results should bear in mind obesity as a cause of a decrease in lung volumes and a case may be made for noting weight routinely when patients are assessed in the laboratory.

V.Conclusion

In the present study it was found that obesity leads to pulmonary function impairment with all its potential complications. Furthermore, as weight reduction is related to pulmonary function gain in obese subjects, obese persons should be encouraged to lose weight to improve pulmonary function.

VI.Acknowledgements

Our sincere thanks to the subjects for their participation in the present study.

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