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Original Article

Evaluation of Dynamic Pulmonary Function in Obese Individuals

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Abstract

Introduction: Obesity is becoming a major health hazard in developed and developing countries. Besides the well-known complication like Diabetes mellitus, hypertension. ischemic heart disease, obesity can affect thorax, diaphragm, abdominal muscles, thereby resulting in altered pulmonary functions.

Objective: To evaluate the effects of obesity on lung functions

Methods: We studied 208 adults of both sex with the age range of 18 to 60. 104 obese subjects were taken as test group (BMI ≥ 25 Kg/m^2) & 104 non obese individuals (BMT 18.5-24.9 Kg/m^2) as control group. Spirometry was performed by using computerized spirometer. Data were expressed as mean & standard deviations. Data were analysed by the help of SPSS version-16. non pair student's 't' test (P values ≤ .05 were considered significant) Pearson correlation analysis & multiple linear regression tests were applied.

Results: FVC% (mean & standard deviation), in obese group (Group A) and non obese group (Group B) were 73.42±8.24, 84.05±5.94 respectively. FEV_1% (mean & standard deviation), in obese group (Group A) and non obese group (Group B) were 74.65±7.29. 84.22±5.95 respectively. FEV_1/FVC% (mean & standard deviation), in obese group (Group A) and non obese group (Group B) were 101.30±9.87, 99.57±11.50 respectively. PEF% (mean & standard deviation), in obese group (Group A) and non obese group (Group B) were 65.98±14.21. 93.53±13.21 respectively. There are statistically significant differences of spirometry results in absolute values and in percentage predicted between two groups, except FEV_1/FVC. There were also significant negative correlation between obesity indices (BMI. WC) and spirometric variables except $FEV_{1/}$FVC%.

Conclusion: Obesity independently affects pulmonary functions.

Key words : Obesity, lung functions.

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Introduction

Across the world the prevalence of non communicable diseases like diabetes mellitus, hypertension and cardiovascular diseases etc. are increasing at an alarming rate. Propelling the upsurge of these, there is increasing prevalence of overweight and obesity. Besides the genetic predisposition, adoption of sedentary life style, inappropriate intake of caloric rich, easily available junk food, and automated working profile has made the environment conducive to the development of obesity. Obesity as per WHO is defined as abnormal or excessive collection of the

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fat in the body to the extent that the health is impaired.Obesity can be classified by calculating BMI (Body Mass Index) using the formula weight/height^2. [1]

According to WHO and International obesity task force, obesity is considered among adult Euripides as ≥ 30Kg/m^2. It can be classified as class-I (30-34.9 Kg/m^2) class- II (35-39.9 Kg/m^2) and class - III (≥ 40Kg/m^2), But the western pacific region office of WHO recommends that amongst Asian adult, BMT ≥ 25 Kg/m^2 is obese. The international association for study of obesity and the international obesity taskforce have suggested lower BMI cut of value for Asians (≤ 25Kg/m^2). Thus obesity can be classified for adult Asians by this cut off value of BMI (Kg/m^2) as class-1(25-29.9 Kg/m^2) class- 11(30 Kg/m^2).[2]

Though BMI is commonly used measure of adiposity, it does not adequately describes the distribution of body fat (which may be more predictive of morbidity), however the pattern of body fat distribution may also influence the lung functions in obese individuals.[3] So the waist hip ratio is also used as a measure of abdominal obesity. Abdominal obesity is defined as a waist—hip ratio above 1 .0 for male and above 0.85 for female in Caucasians. Another simple measure of central obesity, frequently used in clinical practice is waist circumference. The absolute values of waist circumference (>102 centimeters in men and >88 centimeters in women) and the waist hip ratio in male >1.0 cm and >0.85 cm in female is more indicative of morbidity.[4] However waist circumference is the preferred measure of abdominal obesity compared to WHR.[5]

So waist circumference is usually taken as a covariant along with BMI to measure overall obesity. Various studies showed that the ratio of abdominal circumference to hip breadth were negatively associated with FEV_1 and FVC.[6] this suggests that central abdominal obesity also has an impact on spirometry values.

Among lung function tests spirometry is the major tool to define restrictive and obstructive lung diseases. Among the spirornetric values the FEV_1, FVC, FEV_1/FVC ratio, and PEF are the dynamic lung functions which is time dependent.

In obstructive diseases, the FEV_1 falls more than the FVC, so that the ratio between PEV_1/FVC is 70% to 75% of the lower limit of normal. By contrast, in restrictive diseases, the FVC drops more than the FEV_1, and the ratio goes up. If the expiratory time is short (1 to 2 seconds), and the ratio is high (≥ 80% to 90%), the condition is a restrictive ventilatory disorder.[5-8]

Obesity is associated with a varieties of medical disorders including the lesser known but not less important respiratory complication that causes morbidity and functional impairment of daily activities such as airway hyper responsiveness, hypoventilation syndrome, sleep apnea syndrome, exertional dyspnea, respiratory failure (Pickwickian syndrome). Br. Asthma etc. which can be best appreciated by understanding the obese respiratory physiology.[7-9]Obesity may also cause hyper tonicity in abdominal muscles and impairment of the diaphragmatic activity dependent respiratory function leading to manifestation of dyspnoea, sleep apnea and obesity hypoventilation syndrome.[10,11]

Various studies have suggested that pulmonary and chest wall compliance is reduced due to deposition of fat in the chest and abdominal wall, there by causing elastic retraction and reduced dispensability of extra pulmonary structure. [11,12]
In the middle aged people however due to greater fat deposition, increased BMI is associated with decreased pulmonary function[13]. Increase in the fat in the skeletal muscles of obese people leads to decline the skeletal muscle mass and strength of respiratory muscle. Respiratory muscle strength and lung functions are closely associated with body weight and lean body mass.

Patients and Methods

It is a cross-sectional comparative type of observational study conducted on obese patients in Rajshahi Medical College Hospital.

The study was carried out in medicine unit of Rajshahi Medical college hospital from January-2011 to December-2012 for a period of two years. Patients who fulfilled the inclusion and exclusion criteria were included in this study. Sample size was 104 adults of both sexes. 104 non obese subjects were taken as control group. Patients of Aged, 18-60 years, both male & female were enrolled, BMI ≥ 25 Kg/m^2 and waist circumference > 102 cm in male and WC > 88 cm in female as test group, not suffering from any known respiratory or other medical problems, were included.

Results & Observation

A total of 208 persons were included in our study, 104 obese as test group & 104 non obese as control. None had any co-morbidities, excluded by history, clinical examination, & relevant investigations.

Table-I: Basic characteristics of obese (Group-A) and non-obese (Group-B) group. Result are presented in Mean ± SD (Min-Max)

Variables	obese group (Group-A)	Non-obese group (Group-B)	p-value
Age	42.73±5.14	41.17±7.13	0.072
BMI	31.68±2.59	22.41±1.50	0.0001
Waist circumference	104.10±7.31	83.10±4.41	0.0001
Hip circumference	101.31±6.55	96.27±4.11	0.0001
Waist Hip ratio	1.12±0.96	0.85±0.02	0.0001

There were statistically significant difference between anthropometric parameters between two groups (p-<0.0001).

Table- II :Comparison on spirometry between obese group and non-obese group

Comment	Obese		Non-obese		Total	
	N	%	N	%	N	%
Normal	05	2.4	104	50.0	109	52.4
Restrictive	95	45.7	00	00	95	45.7
Obstructive	01	0.5	00	00	01	0.5
Restrictive and mild Obstructive	03	1.4	00	00	03	1.4
Total	104	50.0	104	50.0	208	100.0

In our study the spirometry changes were predominantly restrictive 95(45.7%), obstructive 01(0.5%) and restrictive and mild obstructive were 03(1.4%) out of 104. Normal spirometry were 109(52.4%) out of 208.

Table-III: Comparison of spirometry results between obese (Group-A) and non-obese (Group-B) group. Result are presented in Mean ± SD (Min-Max)

Variables	obese group (Group-A)	Non-obese group (Group-B)	p-value
FVC measured value	2.57±0.57	3.26±0.62	0.0001
FVC% of predicted	73.42±8.24	84.05±5.94	0.0001
FEV_1 measured value	2.59±0.57	3.24±0.63	0.0001
FEV_1 % of predicted	74.65±7.29	84.22±5.95	0.0001
FEV_1 /FVC measured	82.59±8.83	82.03±10.15	0.67
FEV_1 /FVC% of predicted	101.30±9.87	99.57±11.50	0.24
PEF measured value	5.20±1.46	7.70±1.56	0.0001
PEF% of predicted	65.98±14.21	93.53±13.21	0.0001

There were statistically significant differences of spirometry results in absolute values and in percentage predicted between two groups (p-vslue-<0.00010, but there were no statistically significant differences of FEV_1 /FVC in absolute values and in percentage predicted between obese and non-obese groups (p-vslue-0.67, 0.24 respectively).

Table-IV: Compariosm of the study finding between obese (Group-A) and non-obese (Group-B) group. Result are presented in Mean± SD (Min-Max)

Variables	obese group (Group-A)	Non-obese group (Group-B)	p-value
BMI	31.68±2.59	22.41±1.50	0.0001
Waist circumference	104.10±7.31	83.10±4.41	0.0001
Hip circumference	101.31±6.55	96.27±4.11	0.0001
Waist Hip ratio	1.12±0.96	0.85±0.02	0.0001
FVC measured value	2.57±0.57	3.26±0.62	0.0001
FVC% of predicted	73.42±8.24	84.05±5.94	0.0001
FEV_1 measured value	2.59±0.57	3.24±0.63	0.0001
FEV_1 % of predicted	74.65±7.29	84.22±5.95	0.0001
FEV_1 /FVC measured	82.59±8.83	82.03±10.15	0.67
FEV_1 /FVC% of predicted	101.30±9.87	99.57±11.50	0.24
PEF measured value	5.20±1.46	7.70±1.56	0.0001
PEF% of predicted	65.98±14.21	93.53±13.21	0.0001

Table-V: Correlation between BMI and pulmonary variables

Variable pair	Standardized beta coefficient (r)	Correlation	Significance (p-value)
BMIvs FVC%	-0.595	Negative	0.01
BMI vsFEV_1%	-0.575	Negative	0.01
BMI vs	0.091	Positive	NS
BMI vsPEF%	-0.646	Negative	0.01

BMI was negatively & significantly correlated with FVC%, FEV_1%,PEF%. There was no significant correlation between BMI &FEV_1 /FVC%

Table-VI : Correlation between waist circumference and pulmonary variables.

Variable pair	Standardized beta coefficient (r)	Correlation	Significance (p-value)
WC vs FVC%	-0.561	Negative	0.01
WC vsFEV_1%	-0.556	Negative	0.01
WCvsFEV_1/FVC %	0.08	Positive	NS
WCvsPEF%	-0.677	Negative	0.01

Waist circumference was negative & significantly correlated with FVC%, FEV_1% & PEF%. There was no significant correlation between WC & FEV_1/FVC%

Table-VII: Linear Regression analysis.

Constant	Standardized coefficient Beta(significance*)			
	FVC%	FEV_1%	FEV_1/FVC%	PEF%
Age	0.134*	0.125*	0.158*	-0.002
Sex	-0.153*	-0.163*	-0.066	-0.064
BMI	-0.288*	-0.243*	-0.044	-0.188*

WC	-0.283*	0.315*	0.115	-0.230*
WHR	-0.137	-0.136	0.026	-0.350*

FVC%: Age, Sex BMI & WC were independent variable affecting FVC%.FEV_1%: Age, Sex, BMI & WC were independent variable affectingFEV_1%.FEV_1/FVC%: Only age was an independent in affecting PEF%.

Discussion

There are statistically significant differences of spirometry results in absolute values and in percent of predicted between two groups (p value-<**0.0001**), except FEV_1/FVC. It is observed that there are significant reductions in FVC, FEV_1, and PEF in obese subjects when compared to normal individuals. But FEV_1/ FVC% are not altered. The spirometry changes in obese group are predominantly restrictive type of airway dysfunctions.

Naimark A at al. showed that reduced compliance of the total respiratory system in obese subjects was almost entirely related to reduced chest wall compliance.[11,14]

However there are no statistically significant differences in spirometric values between Class-I & Class-11 obese populations. But there aresignificant reductions in spirornetric values in Class-11 obese population.

Our study shows that body composition and fat distribution with associated with lung function in middle-aged subjects, in that BMI & central pattern of fat distribution (WC) are associated with a decrease in lung functions namely (FVC, FEV_1 and PEF) except FEV_1/FVC%. Our study shows a significant inverse relationship between adiposity indices (BMI, WC) and lung functions like FVC, FEV_1, & PEF, which complement the findings of previous studies.[15-17]

There are many studies about the negative association of BMI with FVC & FEV_1.[18-20] which are complementary to our study. Impaired lung function is observed frequently in obese individuals.[21]

The relation between height and pulmonary function was observed previously, height is one of the variables used in estimating lung functions and therefore age related changes in height may significantly affect pulmonary functions.[21]

Compared with the subjects in the normal weight range, lung volume and airway caliber were reduced in linear fashion when compared to subjects with increasing BMI.[22]Our study reveals the same observation.

Lazarus R Gore CJ, et al. conducted a study on Effects of body composition and fat distribution on pulmonary function in adults in the USA at 1998 and showed a decrease in lung functions namely FVC, FEV_1 with increasing BMI, total fat mass and central body fat distribution (waist circumference).[15] which is consistent with our study.

Collins et al.[17] demonstrated that multiple measures of adiposity showed a significant inverse relationship with both spirometry and static lung volumes which are consistent of our study, the altered lung functions were suggestive of a predominantly restrictive type of airway dysfunction, which complements our study.

In our study we have found statistically significant negative correlation between obesity indices (BMI. WC) & pulmonary variables (FEV_1, FVC). We found that as BMI & WC increases, FVC& FEV_1 decreases in linear fashion.Studies of obese individuals not diagnosed with other diseases have suggested that pulmonary and chest wall compliance was reduced due to fat deposition in the chest and abdomen, thereby causing elastic retraction and reduced dispensability of extra pulmonary structures thus decreasing FVC in obese individuals. [12]

The reduction in pulmonary function is due to deposition of fat in abdominal cavity and thoracic cage. This may diminish rib cage movement and thoracic compliance, both of which lead to restrictive respiratory movement. Other mechanism suggested that abdominal fat deposition leads to a redistribution of blood to the thoracic compartment that reduces vital capacity. [23]

Rasool S, Shirwany T et al. conducted a study among office worker, in Pakistan on 2012 and showed that BMI had significant negative association with pulmonary function namely FVC. FEV_1 with the p- <0.0001.[24] which is consistent with our study.

King G, et al. conducted a study in 2005 in England & showed that, lung volume and airway caliber were reduced in subjects with increasing BMI in a linear fashion, Compared with subject in the normal weight range.[22] Our study reveals the same observations.

Airway resistance depends on the elastic recoil of the lung. This tends to increase the airway caliber at high lung volumes and to reduce it at low lung volumes. In addition, closure of small peripheral airways may participate in the increase of resistance to flow of air, thus decreasing FEV_1 in obese individuals. The non elastic work may have been performed to overcome the air flow limitation and the airway resistance that are reportedly increased in patients with obesity. For example, Ruhinsteinet a1[19] examined the maximum expiratory flow (V_{max}) lung volumes and airway resistance using body plethysmography of 103 obese. lifelong nonsmokers without cardiopulmonary disease and compared them with 190 healthy non obese nonsmokers. the forced expirtory in 1 s (FEV_1) of men and women were lower in obese patients compared with non obese subjects. which is consistent with our study.

Changes in weight, body mass and waist circumference were all associated with changes in FEV_1 predominantly in middle age. [25]

In our study there is independent & negative correlation between central pattern of fat distribution (waist circumference) and spiromtric values (FVC & FEV_1 The amount of body fat & central pattern of fat distribution exert mechanical efibct on diaphragmatic descent, reduction in compliance of chest wall, work of breathing and elastic recoil of lung.[26]

A study conducted by Goya S et al. in America on 2005 and found an inverse association between lung function and measures of central adiposity such as the waist circumference (WC) and the waist-hip ratio (WHR).[23] which is consistent with our study.

Conoy D et al, conducted a study on 2004, in the United Kingdom and found that Both FEV_1 and FVC were linearly and inversely related across the entire range of waist hip ratio (measure of central obesity) in both men and women.[27] which is consistent with our study.

Waist circumference has been reported to be a better index of android (abdominal) obesity than waist- hip ratio. Our findings are in line with those of Chinn et al.[28] who observed an association between increase in fat mass (BMI, WC, WHR) and reduction in FVC and FEV_1.

Our study reveals that FEV_1 to FVC ratio is not correlated with obesity indices (BMI, WC, WHR). There is no statistically significant differences of FEV_1 to FVC ratio between obese & non obese group of our study population, which complement other studies. [14,29]

In a study by Sahebjami and Gartside[14],reductions in FEV_1 FVC and maximal inspiratory flow rate in obese subjects were associated with a low MVV. Both FEV_1 and FVC were similarly reduced (in terms of percentage predicted), the FEV_1 and FVC were similarly reduced (in terms of percentage predicted), the FEV_1 to FVC ratio was normal and static lung volumes were reduced, suggesting the reduction may be due to restriction as opposed to air flow obstruction, which is consistent to our study.

In morbidly obese subjects (defined as individuals with a body weight (in kilograms) to height (in centimeters) ratio greater than 0.9 kg/cm), Biringet al.[30] found a reduction in mid expiratory flows and the FEV_1 to FVC ratio, which is not consisted with our study

According to journal by Salome CM, King GG, Berend N. Physology of obesity and effects on lung functions. J ApplPhysiol 108: 206-211, Australia, 2010 the FEV_1 to FVC ratio is usually well preserve or increased even in morbid obesity[29], indicating that both FEV_1 and FVC are affected to the same extent, suggesting the alteration of lung valume may be due to restriction as opposed to air flow obstruction. This is consistent with our study.

In 1998 Lean et al.[31] reported a negative correlation between waist circumference and FEV_1/FVC ratio, which is not consistent with our study.

Lazarus et al conducted a study in 1998 in America & found that the FEV_1 to FVC ratio decreases with increasing BMI in overweight and obese individuals,[15] which is not consistent with our study.

It has been reported that reduction in PEF suggests the presence of peripheral air flow limitation in obese males. Enright PL et al. reported that maximal inspiratory and expiratory pressures which are indices of strength of diaphragm and strength of abdominal and inter costal muscles decreased in obesity. Maximal respiratory pressures decrease with age.[32]

Emigril and Sobol reported increased airway resistance (Raw) in obese subjects and decreased after weight reduction. The hypothesis for Raw in obesity is due to large decrease in resting lung volume (FRC).[33]

Briscoe and Dubois showed those airway conductance (Caw) were linearly related to lung volumes. Studies showed that PEF significantly below normal in obese due to increase in proximal airway resistance but only minimal distal obstruction,[33] our study also reveals that there are significant reduction in PEF values in obese compared to normal subjects.

Conclusion

We see in our study that Obesity independently affects lung function.There are statistically significant reductions of dynamic pulomonary function in obese individuals.There is statistically significant invers linear correlation between adiposity indices (BMI, WC and WHR) & pulmonary variables.Changes of spirometric values in obese subject are predominantly restrictive type of airway dysfunction.

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