

Assessment of Bronchomotor Tone in Normal and Overweight/Obese Normal Subjects

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Abstract

Background: Obesity in children and young adults is on a stupendous rise over the last decade globally making the individual highly susceptible to various diseases. Pulmonary functions are well reported complications of obesity in adults with reduced lung volume & expiratory flow rates being the most frequent reported abnormalities. **Methodology:** This cross sectional analytical study was undertaken in the research lab of the Department of Physiology, M.K.C.G. Medical College over a period of 12 months on 300 students to determine baseline anthropometric measurements and pulmonary function tests using spirometry. Independent 't' test and multiple linear regression in SPSS 20.0 is used to statistically ascertain the aforementioned objective stated in the background. **Results:** VC, ERV, TV, dynamic pulmonary functions; FEV₁, MEF₂₅, along with PIF and MIF₅₀ showed statistically significant decline in overweight/obese individuals. The aforementioned findings of VC, ERV & FEV₁ showed a similar diminished trend in overweight/obese individuals on further evaluation using multiple linear regression analysis. **Conclusion:** Overall most of the pulmonary functions tests showed compromised status in overweight/obese individuals with VC, ERV, TV, FEV₁, MEF₂₅, PIF and MIF₅₀ exhibiting statistically significant reduction. Mechanistically, this can be attributed to the presence of adipose tissue around the rib cage, in the abdomen and visceral cavity loading the chest wall leading to small airway collapse and subsequent lowering of pulmonary function tests.

Keywords: Pulmonary function test, Obesity,

Introduction

Globally, the epidemic of obesity in children and young adults is rapidly increasing, rising by more than 30% over the past decade with its prevalence in India ranges from 10% to 40%¹. It is classically characterized by increased body fat (BF), associated with dyslipidemia, insulin resistance, cell organelles stress, and vascular inflammation. Increased weight makes obese individual

highly susceptible to various diseases.

In general obesity results from greater energy intake than expenditure *with* greater amount of energy from food enter the body than required the body weight increases, and this excess energy is stored as fat thus causing excessive adiposity (obesity). The etiology of obesity is multifactorial and complex with genes determining food intake whilst lifestyle and environmental factors. The rapid rise in obesity off late vehemently suggests the key role of lifestyle and environmental factors because genetic changes could not have occurred so rapidly.

The American Heart Association has reported greater prevalence of hypertension amongst obese individuals. Chronically augmented sympathetic activity is one of the possible mechanisms underlying the pathophysiology

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of hypertension in obese population. The potential abnormalities predisposing these individuals perhaps include enhanced baseline sympathetic activity as well as demented response to sympathetic stimuli.

Pulmonary functions are well reported complications of obesity in adults with reduced lung volume & expiratory flow rates being the most frequent reported abnormalities. Studies exhibited an inverse relationship between BMI and FVC, FEV1. Other parameters such as expiratory and inspiratory flow rates (PEF, MEF50, PIF and MIF50) and MVV also decrease linearly with increasing BMI. Decreases in expiratory flows are most likely to occur once decreased FVC causes flow to move to a lower position on the maximal flow-volume curve.

Paucity of studies available on the pulmonary functions in young obese adults compel us to take the present study with an aim to investigate the derangement of pulmonary function tests in young obese medical students of M.K.C.G. Medical College, Berhampur

Methodology

Study design: This cross sectional analytical study was undertaken to investigate the derangement of sympathetic autonomic parameters and pulmonary functions in young obese students of M.K.C.G. Medical College, Berhampur, Orissa. The research was carried out in the research lab of the Department of Physiology, M.K.C.G. Medical College over a period of 12 months after obtaining written consent from all participants and approval by the institutional ethics committee.

Sample population: 300 participants were included in the analysis after excluding subjects with history of asthma or any other past/concurrent pulmonary illness, history of smoking, symptoms of atopy/allergy. They were divided into 2 groups of 150 each as per the WHO criteria of obesity; BMI of $<25 \text{ kg/m}^2$ (Normal) and $>25 \text{ kg/m}^2$ overweight/obese

Sample size: A sample size of 150 for each group was calculated through Cohen flexible algorithm using Fischer's 'F' distribution by comparing means between two group(s) with ' α '=0.05, ' β '= 80%, ' F '= $0.7 / 2 * 1 = 0.35$ and effect size (es) which is difference b/w the two groups / $2 * \text{within the group SD} = 0.7$

Pulmonary function test analysis using spirometry: A baseline spirometry was done in which both static and dynamic lung function parameters were recorded. All the spirometric measurements were done using FLOWHANDY ZAN 100USB spirometer using ZANsoftware GP1.3.xx based on windows. Before performing the spirometry, the subjects were explained how to perform the test, also there were live demonstration how to perform the test. The subject was comfortably seated with the Flowhandy 100 USB perfectly positioned at his/her mouth level. The subject was connected to ClarityMed PMS 320 cardiac monitor for simultaneous recording of pulse, blood pressure and oxygen saturation of arterial blood (SpO_2). The nose-clip was tightly applied and the subject breathed in and out to the tightly placed mouthpiece through his/her mouth. With the recording system on, the subject had to breathe slowly at least 6-8 times at a rate of about 30 breaths /minute with depth around 0.5 – 1.0 L. After that, the subjects inspired slowly to his total lung capacity and then expire as quick and deep as possible; the expiration must last at least for 6 seconds. A computerised spirometer was used. Flowhandy ZAN 100 USB is an open spirometry system.

Statistical Analysis

Dataset was analyzed using SPSS (Statistical Package for the Social Sciences; version 20.0 for Windows). Independent 't' test was used for comparing continuous variables (anthropometric indices and pulmonary function test parameters) between the groups. Furthermore, multiple linear regression analysis is used to ascertain the findings of the Independent 't' test.

Results

Table 1: Independent ‘t’ test for the comparison of pulmonary function test parameters among non-obese and obese subjects

S. no	Pulmonary function test parameters	Non-obese (n=150) Mean \pm SE	Obese (n=150) Mean \pm SE	‘p’ value	
1.	Static Lung Volume & capacities	Vital capacity (L/min)	4.00 \pm 0.05	3.80 \pm 0.05	<0.01
		Expiratory reserve volume	1.27 \pm 0.03	1.18 \pm 0.03	<0.01
		Inspiratory reserve volume	2.09 \pm 0.04	2.00 \pm 0.04	>0.01
		Tidal Volume	0.59 \pm 0.2	0.70 \pm 0.01	<0.01
		Inspiratory capacity	2.70 \pm 0.04	2.68 \pm 0.03	>0.01
2.	Dynamic Lung Volume & capacities	FVC _{ex}	3.95 \pm 0.62	3.89 \pm 0.61	>0.01
		FEV ₁	3.54 \pm 0.49	3.47 \pm 0.54	<0.01
		FEV ₁ /IVC	89.78 \pm 0.41	89.07 \pm 0.39	>0.01
		FEV ₁ /FVC	89.78 \pm 0.41	89.07 \pm 0.38	>0.01
		MEF ₂₅	7.63 \pm 0.06	7.33 \pm 0.05	<0.01
4.	Mean Expiratory Flow	MEF ₂₅₋₇₅	4.44 \pm 0.07	4.42 \pm 0.08	>0.01
		MEF ₅₀	5.15 \pm 0.08	5.14 \pm 0.08	>0.01
5.	PIF	4.47 \pm 0.11	4.32 \pm 0.11	<0.01	
6.	MIF ₅₀	4.24 \pm 0.11	4.17 \pm 0.11	<0.01	

Values are Mean \pm SE; Independent ‘t’ test: 1. Compared with Non-obese: *p < 0.05, **p < 0.001;

Table 1 shows comparative analysis of pulmonary function test parameters among non-obese and obese subjects using Independent ‘t’ test. Obese subjects exhibit a decline in all the measured static lung volumes and capacities with vital capacity (VC), expiratory reserve volume (ERV), and tidal volume (TV) significantly reduced (p<0.01) in obese as compared to non-obese individuals. A similar pattern of diminished however insignificant dynamic lung volumes and capacities of FEV_{ex}, FEV₁, FEV₁/IVC, FEV₁/FVC and MEF₂₅ is

again observed in obese subjects with only FEV₁ and MEF₂₅ delineating a statistically significant waning pattern. The mean expiratory flow parameters of MEF₂₅₋₇₅ and MEF₅₀ showed no significant between the two groups despite being minutely on a lower side in obese individuals. They also exhibited significant decline in PIF and MIF₅₀.

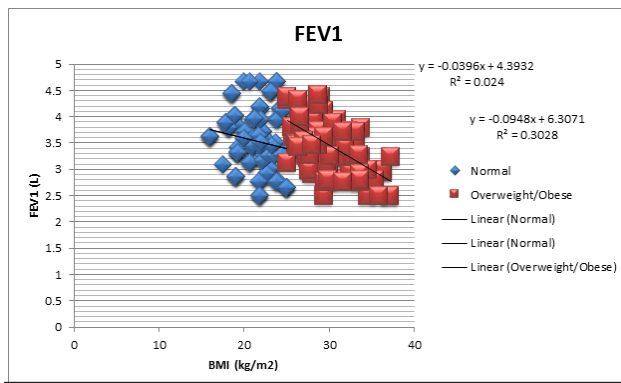
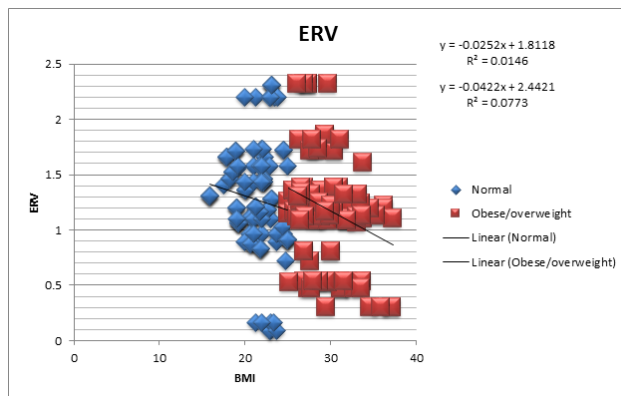
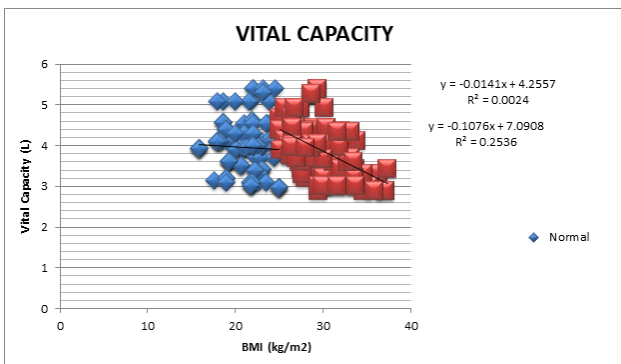


Fig-1 compares dependency of forced expiratory volume in first second (FEV₁) on BMI between non-obese and overweight/obese subjects using multiple linear regression analysis. Among overweight/obese subjects, the slope of best fitted regression line ‘β’ was estimated as -0.09 which means that average baseline FEV₁ decreases by -0.09 L or 9ml for every 1 kg/m² increase in BMI. Furthermore, a value of R²=0.28 vehemently explains 28% of FEV₁ on BMI.



A similar dependency of expiratory reserve volume (ERV) on BMI between non-obese and overweight/obese subjects using multiple linear regression analysis is depicted in Fig-2. Among overweight/obese subjects, the slope of best fitted regression line ‘β’ was estimated as -0.03 which means that average baseline ERV decreases by -0.03 L or 3 ml for every 1 kg/m² increase in BMI. Furthermore, a value of R²=0.03 somewhat explains 3% dependency of ERV on BMI.



Again, Fig-3 shows multiple linear regression analysis of vital capacity (VC) on BMI between non-obese and overweight/obese subjects. Among overweight/obese subjects, the slope of best fitted regression line ‘β’ was estimated as -0.10 which

means that average baseline VC decreases by -0.10 L or 10 ml for every 1 kg/m² increase in BMI. Furthermore, a value of R²=0.21 to a great extent explains 21% dependency of VC on BMI.

Discussion

Obesity was thought to have an influence on lung functions and in turn somewhat correlated with compromised pulmonary function test parameters. Amongst overweight and obese subjects we exhibited a significant decrease in TV, ERV, VC, and FEV₁ as compared to normal individuals. A waning trend in IRV & IC was found in overweight and obese subjects but this reduction is statistically insignificant. Our results are in concordance with the findings of many other studies that have shown various lung volume and capacities especially ERV, FEV₁ and VC decreases with increase in BMI^{1, 2, 6, 8}.

The aforementioned results are in close proximity with many previous studies. For example a study conducted by Richard L Jones et al showed decrease in ERV from a predicted 118% to 55% when BMI increased from 20 kg/m² to 30 kg/m². A similar comprise in FRC from 112% predicted at 20 kg/m² to 84% predicted at 30kg/m² BMI¹. Similar findings are reiterated in a study done by Zerah F et al, showing significant decline in pulmonary functions i.e. TLC, VC, FEV₁, FRC and ERV with rising obesity⁸.

Unlike most of the studies exploring pulmonary function tests in obese subjects, we measured and compared inspiratory flow rates in the form of PIF and MIF₅₀ between overweight/obese and normal individuals. Cases exhibited a significant decline in both PIF and MIF₅₀. Rubenstein et al reported reduced FRC, TLC, ERV, FVC, FEV1 and MEF ratio at low lung volumes and increased RV, RV/TLC ratio and airway resistance in marked obese, non smoker.⁴. Ray and associates studied respiratory function in young obese subjects and found reduced VC, ERV, TLC, FRC and MVV²⁴. Our study showed the effect of BMI on lung volumes and it will help the clinicians to interpret PFT results with normal airway function. About 0.5% decrease in VC, TLC & RV can be expected for each unit increase in BMI.

It’s postulated that presence of adipose tissue around the rib cage, in the abdomen and visceral cavity loads the chest wall subsequently reducing the functional residual capacity (FRC)²⁵. This reduction in FRC and expiratory

reserve volume is detectable, even at a modest increase in weight²⁵. However, obesity has little direct effect on airway calibre which means spirometric variables decline in proportion to the lung volumes rarely falling below the normal range²⁵. Both FEV₁ and FVC declined equally (in terms of percentage predicted), FEV₁ to FVC ratio was found normal whereas static lung volume was found decreased reiterating that this reduction is due to restriction as opposed to air flow obstruction.

Lazarus et al. reiterated the fact that FEV₁ to FVC ratio decreases with increasing BMI in overweight and obese individuals¹⁹. In morbidly obese subjects (defined as individuals with a body weight (in kilograms) to height (in centimetres) ratio greater than 0.9 kg/cm), Biring et al found a reduction in mid-expiratory flows and the FEV₁ to FVC ratio. Obese and overweight individuals most often exhibit marked reduction in the expiratory reserve volume (ERV) reason being the mass loading effect of obesity which consequently diminish FRC. With reduced FRC and a constant RV, decline in ERV is evident. It is appreciated maximum in supine position once the diaphragm ascends in the chest and lungs bearing the weight of lower thorax and abdomen²⁶.

Spirometry is usually normal in mild obesity but expiratory flow, FEV₁ and forced vital capacity (FVC) reduce subsequently with elevated BMI particularly in morbid obesity. Sahebajami et al. showed reduction in FEV₁, FVC and maximal inspiratory flow rate in obese subjects along with significance association with low MVV¹⁵.

Conclusion

Spirometric abnormalities in person with mild to moderate obesity pose somewhat a restrictive defect whereas severe and morbid obesity represents true air flow obstruction. The mechanistic basis can be related to small airway collapse due to decreased lung volumes with increasing obesity or it may be independent.

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Conflicts of Interest: Nil

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