Original Research Article

A cross-sectional analytical study on the association of body mass index to dynamic lung volumes – assessed by digital spirometer in a tertiary care hospital in Chennai

Vasanthakumar M[1], Gnanaprakasam J[2*]

[1,2]Assistant Professor, Department of General Medicine, Kilpauk Medical College and Hospital, Chennai, Tamil Nadu, India
[*]Corresponding author email: **drgnana1978@gmail.com**

International Archives of Integrated Medicine, Vol. 5, Issue 5, May, 2018.

Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 02-05-2018 **Accepted on:** 09-05-2018
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Vasanthakumar M, Gnanaprakasam J. A cross-sectional analytical study on the association of body mass index to dynamic lung volumes – assessed by digital spirometer in a tertiary care hospital in Chennai. IAIM, 2018; 5(5): 121-128.

Abstract

Introduction: Obesity causes reduction of Lung compliance leading to decrease in lung volumes producing mostly a restrictive type of ventilatory defect. Compression of the thoracic cage by excessive fat and increased pooling of blood in pulmonary vasculature mainly contribute towards a reduction in respiratory compliance. Deposition of fat in diaphragm causes mechanical obstruction to the descent of diaphragm thereby causing increased work of breathing and metabolic demand thereby producing breathing difficulty.

The aim of the study: To measure the association of body mass index (BMI) to lung volumes assessed by a digital spirometer.

Materials and methods: Apparently healthy individuals above the age group of 15 years attending Master Health Check-up OP and attenders of in-patients of wards of general medicine department, Govt. Chengalpattu Medical College, Chengalpattu of either gender were recruited. Height and weight were measured and BMI was calculated as kg/m^2. Subjects were categorized as normal (BMI=18.5 to 24.9 kg/m^2); overweight (BMI=25 to 29.9 kg/m^2); obese Class 1 (BMI=30 to 34.9 kg/m^2) and obese class 2 (BMI=35 to 39.9) on the basis of BMI. Lung volumes were measured by digital spirometer and were reported as a percentage of predicted values for forced vital capacity (FVC%), forced

expiratory volume in the first second (FEV1%) and the ratio of FEV1 to FVC (FEV1: FVC). Groups were compared using t-test and ANOVA, the correlation was assessed by Pearson's 'r'.
Results: Significant differences in lung volumes were found in different BMI categories. Obese subjects had significantly lower FVC% and the significant difference calculated by using One Way ANOVA F = 11.9 with p = 0.0001. Similarly, obese participants have significantly lower values of FEV1% when compared to participants of normal BMI. The significant difference calculated by using One Way ANOVA F = 6.46 with p = 0.0001. Gender and age had no significant effect on mean values of PFTs.
Conclusion: Obese individuals in this sample had a significant decline in lung volumes. The presence of nutritional abundance and a sedentary lifestyle, and importantly influenced by genetic endowment, this system increases adipose energy stores and obesity develops which produces adverse health consequences.

Key words

Obesity, Body mass index, Pulmonary function tests, Spirometry, Forced Vital Capacity, Forced Expiratory Volume in 1 second.

Introduction

Obesity has increased globally in an alarming proportion in the last 30 years [1]. Complications due to obesity have surpassed that of many infectious diseases in developed countries. The global epidemic of obesity has also affected Indians [2]. India has been ranked 3rd in the list of top 10 countries with the highest number of obese people just behind U.S and China. Obesity carries significant risk for the development of Hypertension, Diabetes mellitus, Heart diseases, Stroke and some Cancers [3]. Obesity adversely affects Respiratory system also [4]. Obesity causes reduction of Lung compliance leading to decrease in lung volumes producing mostly a restrictive type of ventilatory defect. Compression of the thoracic cage by excessive fat and increased pooling of blood in pulmonary vasculature mainly contribute towards a reduction in respiratory compliance. Deposition of fat in diaphragm causes mechanical obstruction to the descent of diaphragm thereby causing increased work of breathing and metabolic demand thereby producing breathing difficulty. WHO recommends BMI for defining obesity. BMI has been reported to be negatively associated with values for dynamic lung volumes including forced vital capacity (FVC) and forced expiratory volume in first second (FEV1) [5]. Association between BMI and pulmonary function has been previously examined but not many studies are available in India. Therefore, the present study is conducted to measure the relationship between BMI and lung volumes in a sample of the local population.

Materials and methods

Totally 300 volunteers participated in the study for 15 months (June 2014 – August 2015). Above the age of 15 years of apparently healthy individuals attending Master Health Check Up OP and attenders of in-patients of wards of general medicine department, Govt. Chengalpattu Medical College, Chengalpattu.

Inclusion criteria: All apparently healthy individuals of either gender above the age of 15 years of age.

Exclusion criteria:

- Smokers both Current and Ex-smokers and other tobacco users in any other form (chewing, snuffing or water pipe) were excluded from our study. (Ex-smoker is defined as someone who has smoked more than100 cigarettes in his lifetime, does not currently smoke, but used to smoke daily previously)
- Subjects with pre-existing pulmonary (e.g. tuberculosis, bronchial asthma, COPD etc.) disease. (By careful history

taking and subjects with any chest symptoms like a cough, cold, Breathing difficulty, chest pain etc. was excluded from the study).

- Other systemic conditions (e.g. diabetes mellitus, hypertension, etc.) were also excluded.

Proper approval for this study was obtained from Institutional Ethical Committee of Chengalpattu Medical College. Written informed consent was obtained from each participant prior to inclusion in the study. Anthropometric measurements have been done by standard techniques. To ensure correct measurement of height, subjects were asked to straighten their back and observer adjusted the head of the subject in Frankfort plane. Weight was measured by an electronic weighing scale. Subjects removed shoes before measurement of height and weight. BMI was calculated as kg/m2 from height and weight. BMI was used as a measure of obesity and subjects were classified into five categories as follows:

- Underweight = BMI: <18.5 kg/m^2
- Normal= BMI: 18.5 to 24.9 kg/m^2
- Overweight=BMI: 25 to 29.9 kg/m^2.
- Obese Class 1= BMI :30 to 34.9 kg/m^2
- Obese class 2=BM I: 35 TO 39 kg/^{2}

Dynamic lung functions were measured by spirometry. We used a flow measuring type digital spirometer (Spirolab III, Version 3.7, Rome, Italy). Measurements were done in accordance with the latest joint American and European guidelines which have replaced the older ATS and ERS guidelines respectively. All recordings were made between 09:00 AM and 12:00 PM to avoid any presumed diurnal variations. Subjects were instructed regarding the correct way of blowing air into the spirometer and taking a deep breath before forceful expiration prior to the test. Spirometry of all subjects was done in proper sitting position for standardization and uniformity in the interpretation of results. A nose clip was applied to all participants to avoid air leakage from nasal passages. A new disposable mouth-piece was attached to the spirometer before testing each participant. It was ensured that subjects sealed their lips tightly around the mouthpiece and blew out air as hard and fast as possible. The subject was actively encouraged during the procedure to breathe out as long as possible. Tests were discarded and repeated if subjects coughed or blocked the meter with their tongue. The test was repeated for three recordings that met the acceptability and reproducibility criteria and the highest reading was reported. The procedure was abandoned if a participant was unable to produce an acceptable and repeatable spirogram after 8 attempts. Dynamic lung volumes were assessed as

- FVC (measured in liters) and FVC % reported as a percentage of predicted values.
- FEV1 (measured in liters) and FEV1% reported as a percentage of predicted values
- The ratio of FEV1 to FVC (FEV1/FVC%).

Lung volumes were reported as a percentage of predicted value as a linear variable possibly corrected for the effects of age and gender. FVC% and FEV1% were calculated by the following equation: FVC% = measured FVC / reference value for FVCx100. FEV1% = measured FEV1/ reference value for FEV1 x 100. Analysis has been done by comparing the groups using t-test and ANOVA. Correlation is assessed by Pearson’s r method.

Results

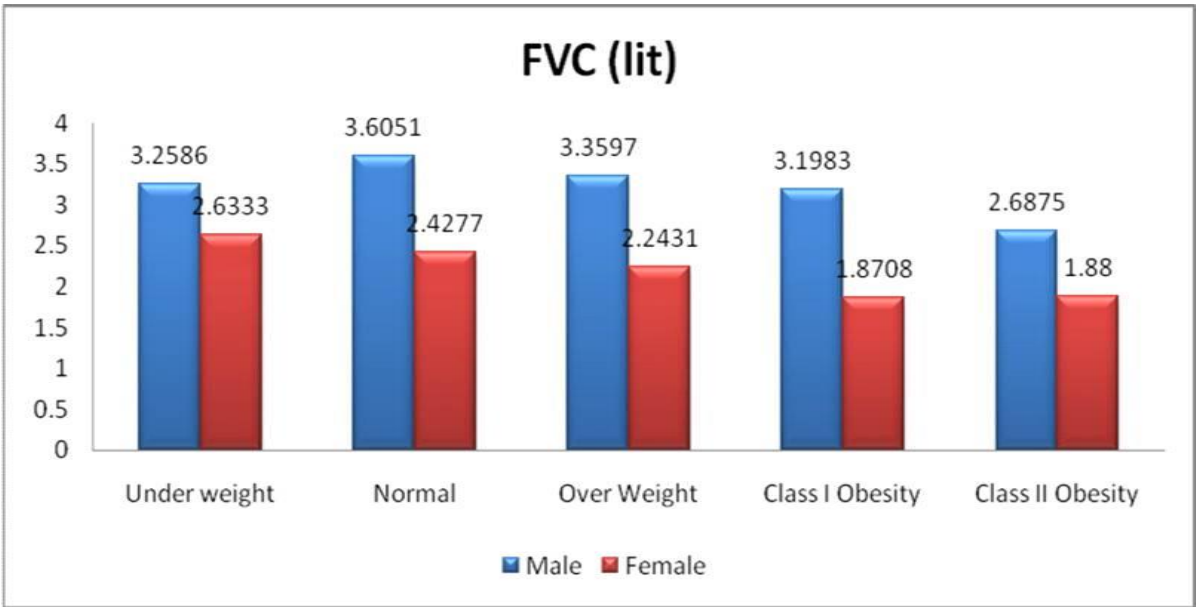
There were 300 participants in this study. The information was collected prospectively. The demographic profile of the participants along with pulmonary function test was collected and entered into MS Excel sheet and analyzed by using SPSS 16.0V. One way ANOVA and Chi sq test are used to find the significance of the Pulmonary functions at 5% level of significance.

The Body mass index was classified by international BMI classification. Most of the people were either overweight or obese. The median BMI was overweight in our study area. Very few participants fall in class II and no one is in class III obese showed that there was 24.4% positive correlation between age and BMI as age increases people are tend become obese, p = 0.001. There was 36% negative correlation between FVC (%) with BMI, That implies that as BMI increases the percentage of FVC tend to decrease, p = 0.001 same way there was 25.3% negative correlation between FEV1 (%) with p = 0.001 but the ration of FEV1/FVC (%) tended to increase as BMI increases there was 16.7% slight positive correlation explained in this study with p = 0.004 (**Table – 1**).

Table - 1: BMI distribution of participants.

BMI	No. of participants	%
Underweight	10	3.3 %
Normal	111	37 %
Over Weight	114	38 %
Class I Obesity	58	19.3 %
Class II Obesity	7	2.3 %
Total	300	100

Graph - 1: Mean value of FVC in litres across sex distribution.

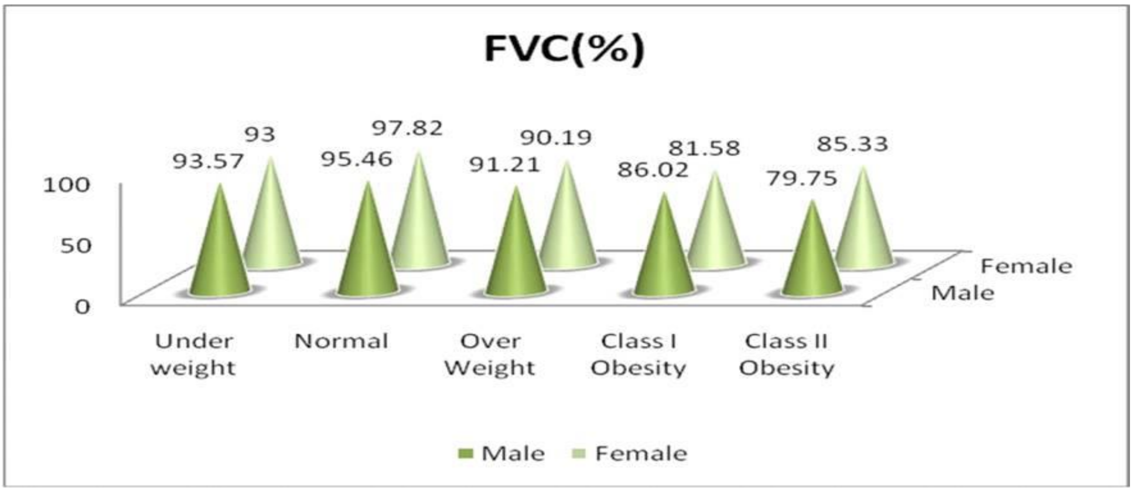


Graph – 1 showed that the absolute values of mean FVC were significantly high in Males in each BMI group. This graph described that the normal group means the value of FVC (%) ranges from 95.93 ± 10.03 and it was decreasing up to 10% to 12% when they become obese. Obese participants (BMI > 30 kg/m^2) had significantly lower values of FVC% when compared to participants of normal BMI < 25 kg/m2 (Obese class I: 85.1 ± 12 and Obese class II: 77.8 ± 15.2 vs Normal: 95.9±10). The significant difference calculated by using One Way ANOVA F = 11.9 with p = 0.0001.

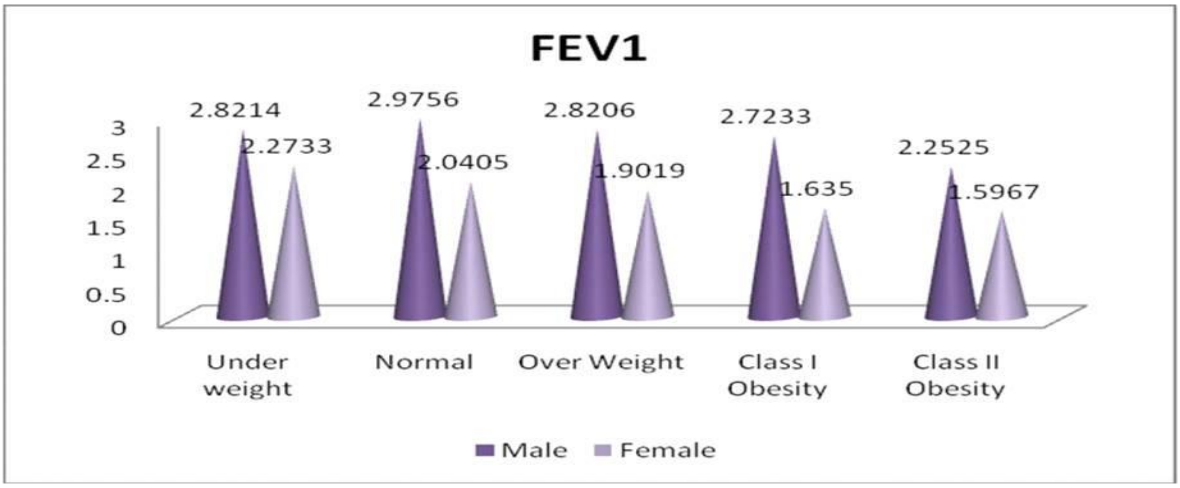
The normal group means the value of FVC (%) ranges from 95.93 ± 10.03 and it was decreasing up to 10% to 12% when they become obese. Obese participants (BMI > 30 kg/m2) had significantly lower values of FVC% when compared to participants of normal BMI < 25 kg/m^2 (Obese class I: 85.1 ± 12 and Obese class II: 77.8 ±15.2 vs Normal: 95.9± 10). The significant difference calculated by using One Way ANOVA F = 11.9 with p = 0.0001 (**Graph – 2**).

Absolute values of mean FEV1 were significantly high in Males in each BMI group (**Graph – 3**). The normal group mean value of FEV1 (%) ranged from 94.89 ± 10.89 and it was decreasing up to 7% to 10% when they become obese. Obese participants (BMI > 30 kg/m^2) had significantly lower values of FEV1% when compared to participants of normal BMI < 25 kg/m^2 (Obese class I: 87.1 ±11.8 and Obese class II: 78.7 ±13.6 vs Normal: 94.9±10.9). The significant difference calculated by using One Way ANOVA F= 6.46 with p = 0.0001 (**Graph – 4**).

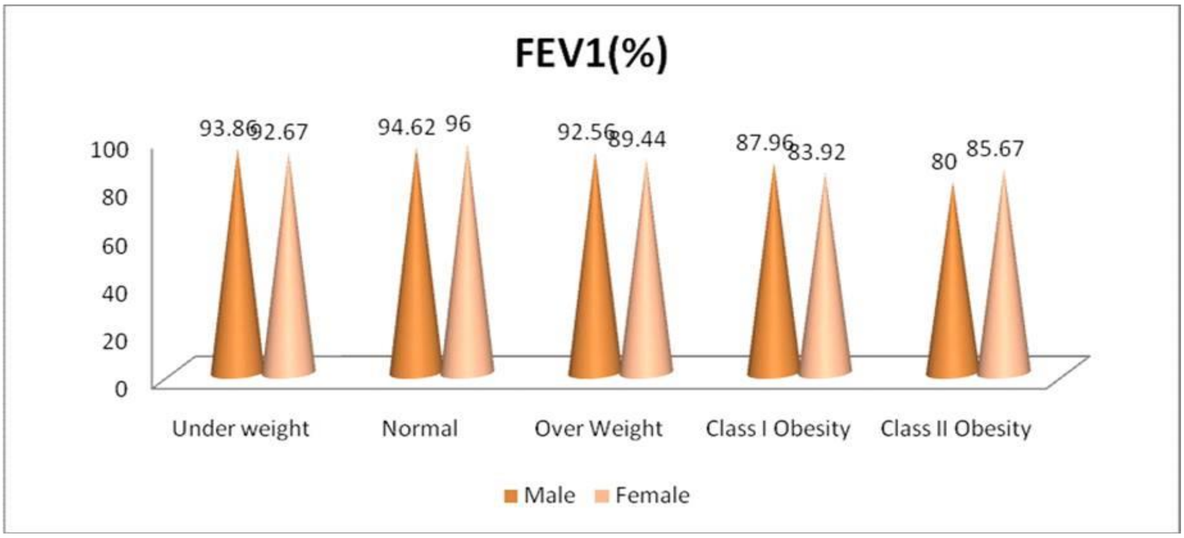
Graph - 2: Mean value of FVC% across sex distribution.



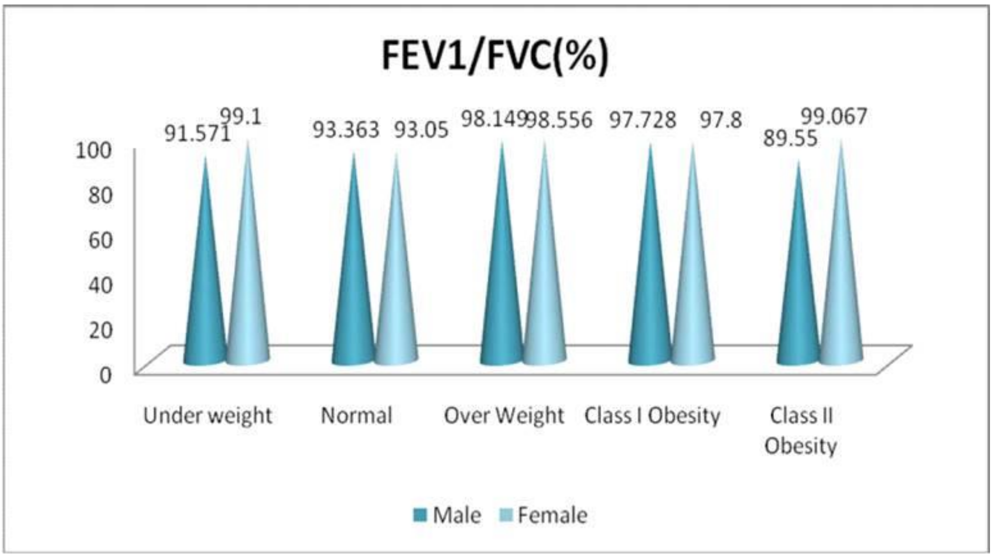
Graph - 3: Mean value of FEV1 in litres across sex distribution.



Graph - 4: Mean value of FEV1% across sex distribution.



Graph - 5: Mean value of FEV1 / FVC% across sex distribution.



Graph - 5 described that the normal group means the value of FEV1/FVC (%) ranges from 93.3 ± 11.23 and it was increasing up to 4% to 5% when they become obese. The significant difference calculated by using One Way ANOVA F = 3.104 with p = 0.016.

Discussion

In our study sample of 300, nearly 60% of the participants are either overweight or obese. This study showed that the problem of obesity in is increasing in India. The results of the study conducted by Haslam D, et al. on obesity in India and National Family Health Survey 2005-2006 showed that Obesity has reached epidemic proportion in India in this 21st century (A, B). Our study also shows similar results. This problem is due to the easy access to the unhealthy high caloric processed food, increase in the middle-class group following globalization and sedentary lifestyle [6]. Our study shows that as age increases BMI also increases. In this study 14% of people are overweight or obese in 11 - 20 years age group whereas it increased to 51% and to 76% in 21-30 and 51-60 age groups respectively. Body weight increased with age [7]. The increase in body weight and BMI with age has also been reported by Kapoor and Tyagi and Tandon in studies conducted in India. Increase in body weight in middle age may be due to the accumulation of fat with age as these subjects have larger appetite leading to increased energy intake, fat-rich diet, and relatively less energy expenditure [8]. Our study shows that there is no significant difference in the distribution of BMI between male and female. This is in contrast to the earlier studies. Lovejoy, et al. reported that Obesity prevalence is generally higher in women than in men, and there is also a sex difference in body fat distribution [9]. The prevalence of overweight and obesity among men and women varies greatly within and between countries, and overall, more women are obese than men. These gender disparities in overweight and obesity are exacerbated among women in developing countries. Sex differences in obesity can be explained in part by the influence of gonadal steroids on body composition and appetite; however, behavioral, socio-cultural and chromosomal factors may also play a role. Significantly lower values of FVC% than participants of Normal BMI. Significantly lower values ofFEV1% than participants of Normal BMI [10]. Significantly high ratio of FEV1/FVC (%) than participants of Normal BMI. The above findings of a decrease in FVC % and FEV1 % in obese participants are consistent with those of some investigators who have shown that lung volumes are significantly lower among subjects in higher BMI groups. These findings are comparable with the study conducted by Bray GA et al in Pakistan [11]. Moreover these results are consistent with results reported by Calle EE, et al. from proactive trial in British adults having family history of T2DM as well as by Morsi who studied Saudi adults with varying degree of asthma and they reported negative correlation of BMI with FVC % and FEV1% [8]. Studying the same association [12], Jousilahti P, et al. reported significant inverse association between BMI and both FVC% and FEV1% in obese subjects only due to lesser involvement in physical activities due to other family and professional commitments. However, the presence of differences in Lung function among BMI categories in our study differs from some others studies [13]. Chan JM, et al. reported no significant difference of FVC%, FEV1% and FEV1/FVC among obese and non-obese females in Brazil detected positive association of BMI with FVC and FEV1 in normal weight Canadians but negative association among overweight and obese subjects [14]. Moreover, Rich-Edwards JW, et al. [15] reported the positive association of BMI with lung function among both males and females in Poland. Association of BMI with Lung function is very diverse and complicated as reported by various researchers across various populations. Thus the exact nature of difference of Lung functions among subjects of various BMI groups and genders in different ethnic groups have been difficult to interpret. But our study clearly shows that Obesity and Dynamic Lung Functions are inversely associated.

Conclusion

By understanding the correlation between the dynamic lung volumes and the BMI we would be able to predict the longevity of the Respiratory capacity of a person. Since human productivity and lung capacity are directly related and obesity is the core issue of many health problems, this study can throw light in formulating a public health policy in preventing obesity.

References

1. Popkin BM, Doak CM. The obesity epidemic is a worldwide phenomenon. Nutr Rev., 1998; 56: 106-114.
2. National Family Health Survey, 2005-06. Mumbai: International Institute for Population Sciences. 2007.
3. Sjostrom CD, Lissner L, Sjostrom L. Relationships between changes in body composition and changes in cardiovascular risk factors: the SOS Intervention Study. Swedish Obese Subjects. Obes Res., 1997; 5: 519–530.
4. Luce JM. Respiratory complications of obesity. Chest, 1980; 78: 626–31.
5. Rubinstein I, Zamel N, DuBarry L, et al. Airflow limitation in morbidly obese, non-smoking men. Ann Intern Med., 1990; 112: 828–32.
6. Haslam D. Obesity: a medical history. Obes Rev., 2007; 8 Suppl 1: 31–6.
7. History of Medicine: Sushruta – the Clinician-Teacher par Excellence" (PDF). Dwivedi, Girish & Dwivedi, Shridhar. 2007. Retrieved 2008-09-19.
8. S weeting HN. Measurement and Definitions of Obesity In Childhood and Adolescence: A field guide for the uninitiated. Nutr J, 2007; 6(1): 32.
9. Gray DS, Fujioka K. Use of relative weight and Body Mass Index for the determination of adiposity. J Clin Epidemiol., 1991; 44(6): 545– 50.
10. Haslam DW, James WP. Obesity. Lancet, 2005; 366(9492): 1197–209.
11. Bray GA. Contemporary diagnosis and management of obesity and the metabolic syndrome. 3rd edition, Newton, PA: Handbooks in health care, 2003.
12. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath Jr CW. Body-mass index and mortality in a prospective cohort of U.S. adults. N Engl J Med., 1999; 341: 1097–1099.
13. Jousilahti P, Tuomilehto J, Vartiainen E, Pekkanen J, Puska P. Body weight, cardiovascular risk factors, and coronary mortality. 15-year follow-up of middle-aged men and women in eastern Finland. Circulation, 1996; 93:1372–5.

14. Chan JM, Rimm EB, Colditz GA, Stampfer MJ, Willett WC. 1994 Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. Diabetes Care, 1994; 17: 961–969.
15. Rich-Edwards JW, Goldman MB, Willett WC, Hunter DJ, Stampfer MJH, Colditz GA, Manson JE. Adolescent body mass index and infertility caused by ovulatory disorder. Am J Obstet Gynecol., 1994; 171: 171– 177.
16. Grodstein F, Goldman MB, Cramer DW. Body mass index and ovulatory infertility. Epidemiology, 1994; 5: 247.