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Alterations in lung functions based on BMI and Body fat % among obese Indian population at National Capital Region

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Abstract:

Background: In India, non-asthmatic hospital admission case study has been conducted to find out the relationship between obesity and lung functions. The main objective of the present study was to find out the alterations in lung functions due to obesity among Indian population living at National Capital Region (NCR).
Materials and Methods: We examined 609 non obese and 211 obese subjects in a cross sectional study from National Capital Region, India with age group ranges between 18-70 years. BMI and body fat % was determined using body fat analyzer. Obese and non-obese subjects were classified based on criteria for BMI and Body fat %. Lung function test viz., FEV_1 and PEFR were conducted using portable spirometer (PIKO-1).
Results: A significant correlation ($p<0.05$) was observed between BMI and PEFR among non-obese male and female subjects. Decline in PEFR and FEV_1 values for corresponding increase in body fat % was observed among study subjects. A significant ($p<0.01$) decline in mean FEV_1 and PEFR was observed among non-obese and obese subjects, compared to their Indian reference standards for lung functions. A significant negative correlation ($p<0.01$) was observed between body fat % and lung functions ($FEV_{1,}$ PEFR).
Conclusion: It is concluded that obese subjects are at a risk of lung function impairment, based on the criteria followed for BMI and body fat %. The study also demonstrate that body fat% classification as a better index for determination of obese subjects compared to BMI classification, with respect to lung function impairments.

Keyword: Body fat%; BMI; lung function; obesity

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Introduction

Obesity has been defined as a chronic medical condition which is characterized by an excessive fat accumulation of human body, causing a general increase in body mass[1]. Obesity is calculated from Body Mass Index (BMI), which is derived from weight in kg divided by height in square meter[1]. World Health Organization reports that obesity has reached epidemic proportions, with 1.9 billion adults being overweight, among which 600 million people are obese[2]. Reports indicate that the global prevalence of obesity has doubled from 1980 to 2014. Approximately 13% of the world's adult population (11% men and 15% women) were obese in 2014[2]. According to the Global Burden of Disease (GBD) study, 2013 the number of overweight and obese people in South Asia are around 200 million with 150 million overweight and obese subjects in India[3]. The 2013 report also shows prevalence of 19.5% overweight and obese in India[3].

The association between obesity and asthma is observed among women[4,5,6-13] and men[14-17]. Obese individuals are more susceptible to obstructive sleep apnea, cardiovascular, pulmonary, hepatic, renal diseases, metabolic alterations and neoplasm[18].Some research groups mentioned earlier has studied the role of adiposity on the respiratory functions, however no consensus ever reached on the physical mechanisms leading to respiratory complications[19].Obesity affects the respiratory functions in many ways. The adipose tissue deposited around the rib cage, abdomen and visceral cavity affects work of breathing and reduces the pulmonary functions[20].

Impedance to diaphragmatic contraction and flattening is imposed by the abdominal adipose tissue, which generates an inspiratory load and imposes pressure on the lungs to optimally inflate and deflate the lungs during tidal respiration[21]. The ribcage movements are also restricted by the thoracic and sub-pleural fat which imposes additional restrictive forces on the lungs. Adiposity can lead to reduced lung compliance[22-24].Obesity can lead to increase in pulmonary blood volume, closure of airways, atelectasis and increased alveolar surface tension[25].

Obesity can result in respiratory function impairment[26], but there are few reports which showed no relationship between them[27,28]. This difference of opinion is mainly due to BMI classification, which will not reflect the distribution or quantity of fat and lean tissue[29]. High BMI in adults was associated with reduced FEV1 and FVC30-32. FEV1/FVC ratios are dependent on alterations in FEV1 and FVC[33,34].

In India, according to the National Family Health Survey (NHFS), the percentage of women in the age group 15 – 49 years who are overweight or obese increased from 10.6% in NFHS-2(1998-99) to 14.8% in NHFS-3(2005-2006). The NHFS-3 data also reports 12.1% men in the age group 15 – 49 years being overweight or obese[35]. According to a recent estimates, over 74% of the urban Indians are overweight[36]. Another study showed that one in every five men and one in every seven women in India are extremely obese in India with average BMI being 27.5 kg/m2 and 30 kg/m2 respectively. In India, chronic respiratory disease accounts for 7 per cent of all deaths and 3 per cent of DALY'S[37]. In an earlier study, tobacco smoking habit was associated with chronic respiratory morbidity[38]. Environmental tobacco smoke[39] and biomass fuels[40,41] are associated with chronic respiratory morbidity among women and children[42].

Differences in pulmonary function in normal people may be due to ethnic origin, physical activity, environmental conditions, living at high altitude, tobacco smoking, age, height, sex, and socioeconomic status.' The wide range of geographical and climatic conditions in India where regional differences in lung function among healthy individuals can be observed[43].Obesity related asthma was observed among adult and paediatric population[4,5]. Even though there are studies which show relationship between asthma and adiposity, there are few studies with difference of opinion[30,44-49].

Considering the proportion of overweight and obese people in India as well as respiratory health problems among Indians, a cross sectional study was conducted to understand the association between obesity and lung function status among residents of National Capital Region, India.

Materials and Methods

Study design and participants

A cross-sectional study was done between 1st March- 31st September 2010. The eligible subjects were selected from the semi-rural areas of Gurgaon and Noida region in the National Capital Region (NCR), New Delhi, India. Households were selected using systematic sampling scheme using the list of all households in the region from government agencies. The identified residents were asked to participate based on their voluntary informed consent. Participants were free to withdraw at any stage of the study.

Data collection

The personal details comprising of information regarding age, height, weight, body composition measurements (BMI and Body Fat%) and personal habits were recorded through structured personal interviews. BMI and Body Fat% (BF%) was measured using a body fat analyzer (HBF-352, Omron Health care Co., Kyoto, Japan). BF % and Body weight was measured to the nearest 0.1 per cent and 0.1 kg respectively in light indoor clothing without shoes, using body fat analyzer. Height was measured using portable Stadiometer.

BMI > 25 kg/m^2 were considered as obese subjects and BMI < 25 kg/m^2 were taken as non-obese, based on the Indian guidelines issued by the Ministry of Health, Govt. of India[50]. In case of BF%, the criteria of obesity were taken separately for male and female subjects. In case of male subjects BF% > 25 were considered obese and < 25 as non-obese. For female subjects, obesity was defined as BF% > 39 [51].

Lung function tests FEV_1 (Forced Expiratory Volume in 1 second) and PEFR (Peak Expiratory Flow Rate) for assessment of pulmonary impairment were carried out using a portable Spirometer (PIKO-1, UK) following the recommendation of the American Thoracic Society standards). Each subject performed the lung function test three times after allowing necessary rest between repetitions. The best value of PEFR and FEV_1 among the three tests for each subject were recorded. Results of lung function parameters were compared with their predicted values for Indian population[52].

Inclusion criteria

The inclusion criteria for the selection of subjects were age group between 18 and 70 years who live in the study locations. A total of 820 subjects were found eligible for the study.

Exclusion criteria

Subjects taking any form of medication were excluded from the study. Further all the subjects who doesn't follow the inclusion criteria were excluded from the study.

Outcome variable

The main outcome variable of the study was the status of the lung function parameters (FEV_1 and PEFR).

Explanatory variable

Body composition variables (BMI and BF%) were taken as the explanatory variables.

Ethical Statement

Ethical clearance was obtained from CSIR-Indian Institute of Toxicology Research- Institutional Human Ethical Committee (IHEC), Lucknow, India before starting the study.

Sample size calculation

In a pilot study done prior to the study with 100 cases showed Proportion of respiratory symptoms in group I = .25,Proportion of Respiratory symptoms in group II = .16. With risk difference = 0.09, Power(%) = 80, alpha Error(%) = 5, required sample size for each arm was 315.

Data management and statistical analysis

Subjects were divided into obese and non-obese as per their BMI and BF% classification. Descriptive statistics (mean, standard deviation and range) was calculated for all the continuous variables. All the categorical variables were presented as frequencies with their percentage. Student's t test was used to check for significance between the mean values of the quantitative parameters (age, height, weight, FEV_1 and PEFR). Age adjusted comparisons were undertaken using generalized linear models. Smoking status of the study subjects has been adjusted in the analysis. Chi square was used to test the significance in case of categorical variables Regression models were fitted taking FEV_1 and PEFR as the dependent variables and BMI & BF% as the independent variables. Models were then used to predict the values of FEV_1 and PEFR with increasing or decreasing values of body composition factors. The criterion of significance was taken as $p<0.05$. All statistical calculations were done using STATA IC 13 software.

Results

A total of 820 eligible subjects were selected for the study based on the inclusion and exclusion criteria. Table 1 summarizes the characteristics of the study subjects stratified according to BMI and BF% classification for obese and non-obese. When stratified according to BMI, a total of 609 subjects were non-obese and 211were obese according the criteria adopted. Prevalence of obesity was higher among females ($p<0.01$). Significantly higher number of obese males was found in the stratification by BF%. Obese subjects based on BMI and body fat % were older (as per their average age) than non-obese subjects ($p<0.01$). Hence, age was adjusted for statistical analysis. Height was more or less similar in both groups. Body weight among obese subjects was higher with BMI and body fat % classification. Smoking was significantly more ($p<0.01$) among non-obese subjects in BMI classification. Hence, smoking effect was adjusted for statistical analysis. Respiratory symptoms were more ($p<0.05$) among obese subjects.

Table 2 shows decline in PEFR and FEV_1 predicted % for increase in body fat %. The percentage fall in the PEFR was 1.6 - 4.8% corresponding to increase in body fat %. In case of percent predicted $FEV_{1,}$ the decline was observed from 1.5 - 4.2% corresponding to increase in body fat%. No such alteration in lung function was observed for increase in BMI. Figure 1 showed significant decline in observed FEV_1 and PEFR among non-obese and obese subjects ($p<0.01$) with respect to both body fat % and BMI classification. Pooled analysis shows negative correlation ($p<0.01$) between increase in body fat % and pooled values of $FEV_1$and PEFR among study subjects (Figure2). This relationship was not observed for BMI classification.

Table1: Characteristics of the subjects stratified on the basis of BMI and Body Fat% categories

Parameters	Body Mass Index			Body Fat %		
	Non-Obese (N = 609)	Obese (N = 211)	p value	Non-Obese (N = 678)	Obese (N = 142)	p value
Sex			$p < 0.01$			$p < 0.01$†
Male n(%)	330 (54.2)	85 (40.3)		308 (45.4)	107 (75.4)	
Female n(%)	279 (45.8)	126 (59.7)		370 (54.6)	35 (24.6)	
Age (yrs)	36.1 ± 14.3 (18 – 70)	41.1 ± 12.1 (18 – 70)	$p < 0.01$	35.5 ± 13.5 (18 – 70)	46.2 ± 12.8 (18 – 70)	$p < 0.01$†
Height (cm)	161.4 ± 9.7 (115 – 186)	160.63 ± 9.20 (139 – 184)	$p = 0.3$	160.8 ± 9.4 (115 – 186)	162.9 ± 10.2 (135 – 184)	$p < 0.05$†
Weight (kg)	52.7 ± 9.6 (16.2 – 80.8)	71.6 ± 10.0 (40.2 – 103)	$p < 0.01$	54.8 ± 10.7 (16.2 – 91.6)	70 .6 ± 13.6 (33.8 – 103)	$p < 0.01$†
Smoker n (%)	99 (16.3)	15 (7.1)	$p < 0.01$	93 (13.7)	21 (14.8)	$p = 0.7$
Respiratory symptoms n (%)	111 (18.2)	38 (18.0)	$p = 0.9$	114 (16.8)	35 (24.6)	$p < 0.05$†

† p<0.05 Statistically significant

Table 2: Alterations in the predicted lung function values for increase in Body Fat%

Body Fat% quartiles	Difference in predicted PEFR	% fall in predicted PEFR	Difference in predicted FEV_1	% fall in predicted FEV_1
5 (min) – 19.9	0.5	1.6	0.4	1.5
19.9 – 26.5	0.7	2.4	0.6	2.1
26.6 – 33.4	0.9	3.1	0.8	2.8
33.4 – 48.3 (max)	1.4	4.8	1.2	4.2

Fig 1: Lung function status of subjects with respect to BMI and Body Fat% categories

**** p<0.01**

Discussion

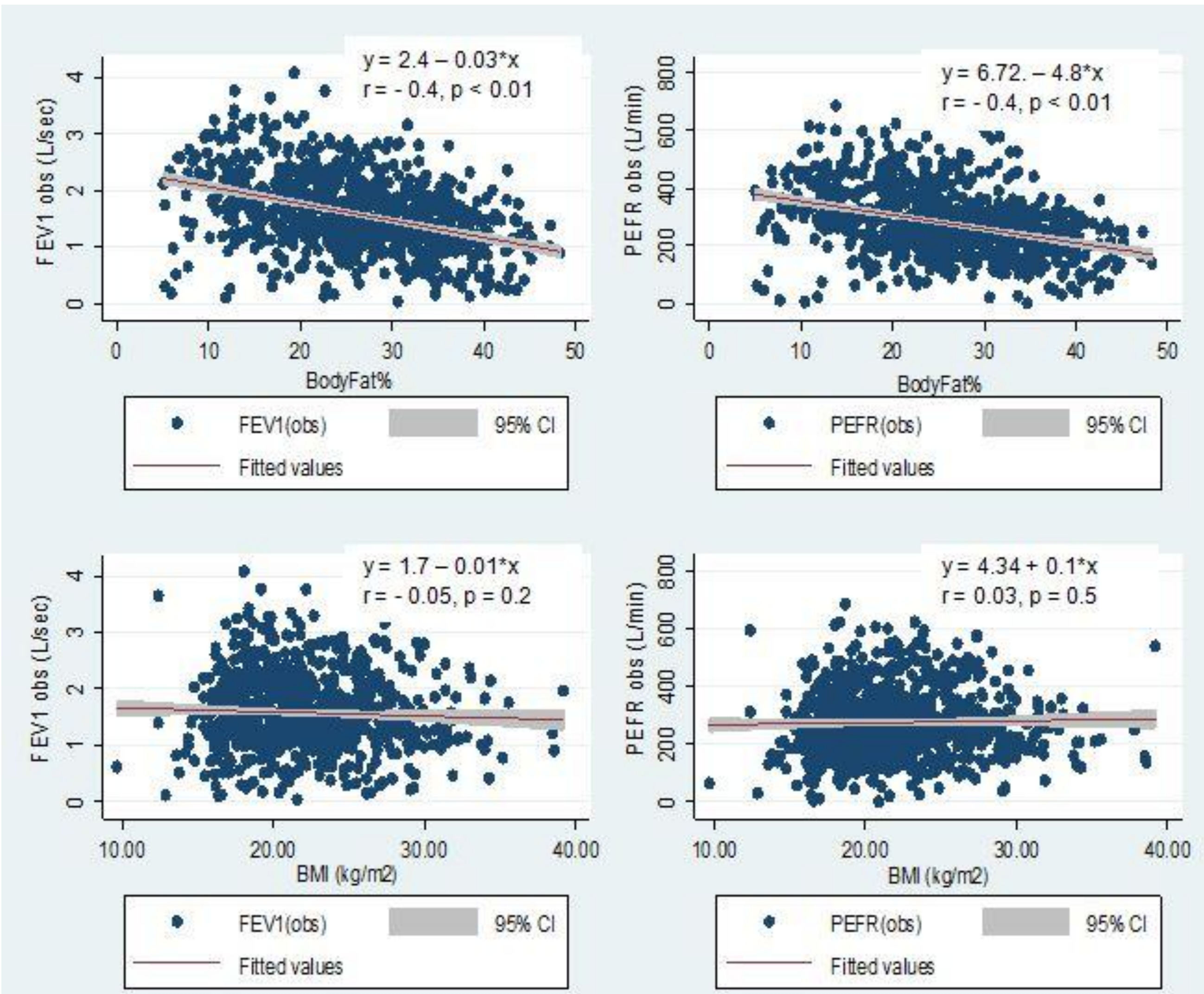
This study is the first report on the risk of decline in FEV_1, PEFR among obese subjects in Indian population, based on the criteria followed for BMI and body fat %. In an earlier Indian study a similar report on decline in FEV_1 based on BMI classification were reported in non-asthmatic hospital based study[58]. The significance of the present study is the selection of subjects who are residents at National Capital Region and not having any previous history of serious medical illnesses. The study also demonstrate that body fat% classification as a better index for determination of obese subjects compared to BMI classification, with respect to lung function impairments. The effects of obesity on the lung function values have not been found to be consistent in earlier studies[58]. Other studies (other than from India) have reported effects of obesity on asthma [53], reduced FRC and expiratory reserve volume detected even at modest increase in weight[25], significant inverse relation between BMI and values of VC and TLC and the values of FRC and ERV decreasing exponentially with BMI[54], reduced FRC in obese subjects[55] and extreme obesity associated with a reduction in ERV, FVC, FEV_1, FRC, FEF_{25-75}%, and MVV[56]. Several studies reported no significant differences in FEV_1, FVC, FEV_1/FVC ratio and FEF_{25-75} between obese and non-obese subjects[1,57,58].

Obesity is the combination of fatty mass and body masculinity, whereas BMI can interpret only body structure[57,59,60].The effects of body fat% on the pulmonary function values have also been examined in the present study, a topic which hasn't received much attention. Our study showed body fat% to be a better indicator of the lung function alterations as compared to BMI. Generally FEV_1 and FVC are within the normal range among healthy obese subjects[1,25]. Restrictive type of lung function abnormalities are frequently observed among obese subjects responsible for alteration in respiratory mechanics[60]. Abdominal and thoracic fat deposition are associated with work of breathing[60,61]. Our results indicate a significant decline in the predicted values of both FEV_1 and PEFR with increasing body fat%. Studies conducted on the lung function status of patients have indicated upper body obesity has a more severe impact on the lung volumes as compared to obese patients with lower body obesity[57]. Increase in body fat is associated with decline in FEV_1 and FVC by 10 –15 mL[28,60].

Therefore it can be presumed that adiposity impacts negatively on the lung functions [57,59,60]. Abdominal obesity is related to FEV_1 and FVC, whereas body fat alone does not show any relationship with lung functions[60].

Exercise regimens may be adopted as an intervention strategy among obese subjects to improve health. Exercise may generate deep inspiration and tidal volume which reverses broncho-constriction[62,63]. Reductions in lung function values can be associated to the ambient air pollution in the study locations. Lack of individual exposure data is a limitation of the study.

Fig 2: Correlation between lung function parameters with BMI and Body Fat% (pooled data)



Conclusions:

It is concluded that obese subjects are at a risk of lung function impairment, based on the criteria followed for BMI and body fat %. The study also demonstrate that body fat% classification as a better index for determination of obese subjects compared to BMI classification, with respect to lung function impairments.

Limitation of the study: The study subjects were restricted to National Capital region which can be considered as a limitation. The data was not adjusted to exposure of air pollutants in the study locations, which can be considered as another limitation of the study.

Future scope of the study: Future studies must be extended to a larger, geographically and anthropometrically diverse national representative population in India, to enable a better policy decision on this aspect. Further studies are required on the association of obesity on lung functions to find out its relationship in a larger, national representative sample size in India.

What is already known on this topic: Previous studies showed an association between body composition factors like BMI, body fat % and its effects on lung functions. These studies are focused among patients at hospital settings.

What this study adds: This is the first population-based study on the relationship between body composition factors and alterations in lung functions among Indian population especially residents at National Capital Region with a large sample size.

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Author's contributions: RK, CK and AKS designed the study, drafted the manuscript and revised it. Data collection was done by VB, RK and CK. BS provided expert statistical support and revision of the manuscript. All authors have approved the final manuscript.

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References

1. Al Ghobain M. The effect of obesity on spirometry tests among healthy non-smoking adults. BMC Pulm Med 2012;12:10.
http://dx.doi.org/10.1186/1471-2466-12-10
PMid:22436173 PMCid:PMC3337807

2. Obesity and overweight. WHO Media centre.[online] 2015January [cited 2015 March 13]. Available from: URL: http://www.who.int/mediacentre/factsheets/fs311/en/

3. Overweight and Obesity Viz. Institute for Health Metrics and Evaluation (IHME).University of Washington, Seattle, WA.[online] 2014 May [cited 2015 March 13]. Available from:URL: http://vizhub.healthdata.org/obesity.

4. Dixon AE, Holguin F, Sood A, et al. An official American Thoracic Society Workshop report: obesity and asthma. Proc Am Thorac Soc 2010;7:325-35.
http://dx.doi.org/10.1513/pats.200903-013ST
PMid:20844291

5. Dorevitch S, Conroy L, Karadkhele A, Rosul L, Stacewicz-Sapuntzakis M, Fantuzzi G. Associations between obesity and asthma in a low-income, urban, minority population. Ann Allergy Asthma Immunol 2013;110:340-6.
http://dx.doi.org/10.1016/j.anai.2013.02.001
PMid:23622004

6. Nystad W, Meyer HE, Nafstad P, Tverdal A, Engeland A. Body mass index in relation to adult asthma among 135,000 Norwegian men and women. Am J Epidemiol 2004;160:969-76.
http://dx.doi.org/10.1093/aje/kwh303
PMid:15522853

7. Chen Y, Dales R, Krewski D, Breithaupt K. Increased effects of smoking and obesity on asthma among female Canadians: the National Population Health Survey, 1994-1995. Am J Epidemiol 1999;150:255-62.
http://dx.doi.org/10.1093/oxfordjournals.aje.a009996
PMid:10430229

8. Shaheen SO, Sterne JA, Montgomery SM, Azima H. Birth weight, body mass index and asthma in young adults. Thorax 1999;54:396-402.
http://dx.doi.org/10.1136/thx.54.5.396
PMid:10212102 PMCid:PMC1763790

9. Mishra V. Effect of obesity on asthma among adult Indian women. Int J Obes Relat Metab Disord 2004;28:1048-58.
http://dx.doi.org/10.1038/sj.ijo.0802700
PMid:15197412

10. Camargo CA, Jr., Weiss ST, Zhang S, Willett WC, Speizer FE. Prospective study of body mass index, weight change, and risk of adult-onset asthma in women. Arch Intern Med 1999;159:2582-8.
http://dx.doi.org/10.1001/archinte.159.21.2582
PMid:10573048

11. Kronander UN, Falkenberg M, Zetterstrom O. Prevalence and incidence of asthma related to waist circumference and BMI in a Swedish community sample. Respir Med 2004;98:1108-16.
http://dx.doi.org/10.1016/j.rmed.2004.03.022
PMid:15526812

12. Romieu I, Avenel V, Leynaert B, Kauffmann F, Clavel-Chapelon F. Body mass index, change in body silhouette, and risk of asthma in the E3N cohort study. Am J Epidemiol 2003;158:165-74.
http://dx.doi.org/10.1093/aje/kwg131
PMid:12851230

13. Huovinen E, Kaprio J, Koskenvuo M. Factors associated to lifestyle and risk of adult onset asthma. Respir Med 2003;97:273-80.
http://dx.doi.org/10.1053/rmed.2003.1419
PMid:12645835
14. Arif AA, Delclos GL, Lee ES, Tortolero SR, Whitehead LW. Prevalence and risk factors of asthma and wheezing among US adults: an analysis of the NHANES III data. Eur Respir J 2003;21:827-33.
http://dx.doi.org/10.1183/09031936.03.00054103a
PMid:12765429
15. Braback L, Hjern A, Rasmussen F. Body mass index, asthma and allergic rhinoconjunctivitis in Swedish conscripts-a national cohort study over three decades. Respir Med 2005;99:1010-4.
http://dx.doi.org/10.1016/j.rmed.2005.02.004
PMid:15950142
16. Celedon JC, Palmer LJ, Litonjua AA, et al. Body mass index and asthma in adults in families of subjects with asthma in Anqing, China. Am J Respir Crit Care Med 2001;164:1835-40.
http://dx.doi.org/10.1164/ajrccm.164.10.2105033
PMid:11734432
17. Beuther DA, Sutherland ER. Overweight, obesity, and incident asthma: a meta-analysis of prospective epidemiologic studies. Am J Respir Crit Care Med 2007;175:661-6.
http://dx.doi.org/10.1164/rccm.200611-1717OC
PMid:17234901 PMCid:PMC1899288
18. Melo LC, Silva MA, Calles AC. Obesity and lung function: a systematic review. Einstein (Sao Paulo) 2014;12:120-5.
http://dx.doi.org/10.1590/S1679-45082014RW2691
19. Sue DY. Obesity and pulmonary function: more or less? Chest 1997;111:844-5.
http://dx.doi.org/10.1378/chest.111.4.844
PMid:9106556
20. Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. Journal of applied physiology (Bethesda, Md : 1985) 2010;108:206-11.
http://dx.doi.org/10.1152/japplphysiol.00694.2009
PMid:19875713
21. Naimark A, Cherniack RM. Compliance of the respiratory system and its components in health and obesity. J Appl Physiol 1960;15:377-82.
PMid:14425845
22. Pelosi P, Croci M, Ravagnan I, et al. The effects of body mass on lung volumes, respiratory mechanics, and gas exchange during general anesthesia. Anesth Analg 1998;87:654-60.
http://dx.doi.org/10.1097/00000539-199809000-00031
http://dx.doi.org/10.1213/00000539-199809000-00031
PMid:9728848
23. Pelosi P, Croci M, Ravagnan I, Vicardi P, Gattinoni L. Total respiratory system, lung, and chest wall mechanics in sedated-paralyzed postoperative morbidly obese patients. Chest 1996;109:144-51.
http://dx.doi.org/10.1378/chest.109.1.144
PMid:8549177
24. Hedenstierna G, Santesson J. Breathing mechanics, dead space and gas exchange in the extremely obese, breathing spontaneously and during anaesthesia with intermittent positive pressure ventilation. Acta Anaesthesiol Scand 1976;20:248-54.
http://dx.doi.org/10.1111/j.1399-6576.1976.tb05047.x
http://dx.doi.org/10.1111/j.1399-6576.1976.tb05036.x
PMid:785930
25. Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. J Appl Physiol (1985) 2010;108:206-11.
http://dx.doi.org/10.1152/japplphysiol.00694.2009
PMid:19875713
26. Ochs-Balcom HM, Grant BJ, Muti P, et al. Pulmonary function and abdominal adiposity in the general population. Chest 2006;129:853-62.
http://dx.doi.org/10.1378/chest.129.4.853
PMid:16608930
27. Lazarus R, Gore CJ, Booth M, Owen N. Effects of body composition and fat distribution on ventilatory function in adults. Am J Clin Nutr 1998;68:35-41.
PMid:9665094
28. Chen Y, Rennie D, Cormier YF, Dosman J. Waist circumference is associated with pulmonary function in normal-weight, overweight, and obese subjects. Am J Clin Nutr 2007;85:35-9.
PMid:17209174
29. Scott HA, Gibson PG, Garg ML, et al. Relationship between body composition, inflammation and lung function in overweight and obese asthma. Respir Res 2012;13:10.
http://dx.doi.org/10.1186/1465-9921-13-10
PMid:22296721 PMCid:PMC3329414
30. Schachter LM, Salome CM, Peat JK, Woolcock AJ. Obesity is a risk for asthma and wheeze but not airway hyperresponsiveness. Thorax 2001;56:4-8.
http://dx.doi.org/10.1136/thorax.56.1.4
PMid:11120896 PMCid:PMC1745919
31. Sin DD, Jones RL, Man SF. Obesity is a risk factor for dyspnea but not for airflow obstruction. Arch Intern Med 2002;162:1477-81.
http://dx.doi.org/10.1001/archinte.162.13.1477
PMid:12090884
32. Zerah F, Harf A, Perlemuter L, Lorino H, Lorino AM, Atlan G. Effects of obesity on respiratory resistance. Chest 1993;103:1470-6.
http://dx.doi.org/10.1378/chest.103.5.1470

PMid:8486029
33. Lazarus R, Sparrow D, Weiss ST. Effects of obesity and fat distribution on ventilatory function: the normative aging study. Chest 1997;111:891-8.
http://dx.doi.org/10.1378/chest.111.4.891
PMid:9106566
34. Rubinstein I, Zamel N, DuBarry L, Hoffstein V. Airflow limitation in morbidly obese, nonsmoking men. Ann Intern Med 1990;112:828-32.
http://dx.doi.org/10.7326/0003-4819-112-11-828
PMid:2378649
35. National Family Health Survey (NHFS-3). India: International Institute for Population Studies; 2005-06.
36. 5 out of 10 Urban Indians are trying to lose weight.Fit Ho Healthy Diet Online, NDTV.[online] 2014 August 18 [cited 2015 March 13]. Available from:URL:http://food.ndtv.com/health/5-out-of-10-urban-indians-are-trying-to-lose-weight-695867
37. Srinath Reddy K, Shah B, Varghese C, Ramadoss A. Responding to the threat of chronic diseases in India. Lancet 2005;366:1744-9.
http://dx.doi.org/10.1016/S0140-6736(05)67343-6
38. Jindal SK. Emergence of chronic obstructive pulmonary disease as an epidemic in India. Indian J Med Res 2006;124:619-30.
PMid:17287549
39. Jaakkola MS. Environmental tobacco smoke and health in the elderly. Eur Respir J 2002;19:172-81.
http://dx.doi.org/10.1183/09031936.02.00270702
PMid:11852892
40. Brundtland GH. Health and the World Conference on Sustainable Development. Bull World Health Organ 2002;80:689.
PMid:12378284 PMCid:PMC2567616
41. Orozco-Levi M, Garcia-Aymerich J, Villar J, Ramirez-Sarmiento A, Anto JM, Gea J. Wood smoke exposure and risk of chronic obstructive pulmonary disease. Eur Respir J 2006;27:542-6.
http://dx.doi.org/10.1183/09031936.06.00052705
PMid:16507854
42. Mahesh PA, Jayaraj BS, Prabhakar AK, Chaya SK, Vijayasimha R. Prevalence of chronic cough, chronic phlegm & associated factors in Mysore, Karnataka, India. Indian J Med Res 2011;134:91-100.
PMid:21808140 PMCid:PMC3171924
43. Vijayan VK, Kuppurao KV, Venkatesan P, Sankaran K, Prabhakar R. Pulmonary function in healthy young adult Indians in Madras. Thorax 1990;45:611-5.
http://dx.doi.org/10.1136/thx.45.8.611
PMid:2402724 PMCid:PMC462643
44. Guerra S, Sherrill DL, Bobadilla A, Martinez FD, Barbee RA. The relation of body mass index to asthma, chronic bronchitis, and emphysema. Chest 2002;122:1256-63.
http://dx.doi.org/10.1378/chest.122.4.1256
PMid:12377850
45. Chen Y, Rennie D, Cormier Y, Dosman J. Sex specificity of asthma associated with objectively measured body mass index and waist circumference: the Humboldt study. Chest 2005;128:3048-54.
http://dx.doi.org/10.1378/chest.128.4.3048
PMid:16236985
46. Hancox RJ, Milne BJ, Poulton R, et al. Sex differences in the relation between body mass index and asthma and atopy in a birth cohort. Am J Respir Crit Care Med 2005;171:440-5.
http://dx.doi.org/10.1164/rccm.200405-623OC
PMid:15557135
47. Schachter LM, Peat JK, Salome CM. Asthma and atopy in overweight children. Thorax 2003;58:1031-5.
http://dx.doi.org/10.1136/thorax.58.12.1031
PMid:14645967 PMCid:PMC1746556
48. Bustos P, Amigo H, Oyarzun M, Rona RJ. Is there a causal relation between obesity and asthma? Evidence from Chile. Int J Obes (Lond) 2005;29:804-9.
http://dx.doi.org/10.1038/sj.ijo.0802958
PMid:15824747
49. Vazquez-Nava F, Morales Romero J, Crodova Fernandez JA, et al. Association between obesity and asthma in preschool Mexican children. ScientificWorldJournal 2010;10:1339-46.
http://dx.doi.org/10.1100/tsw.2010.134
PMid:20623094
50. India reworks obesity guidelines, BMI lowered.iGOVERNMENT.[online] 2008 November 26 [cited 2015 March 13]. Available from: URL:http://www.igovernment.in/news/26259/india-reworks-obesity-guidelines-bmi-lowered
51. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr 2000;72:694-701.
PMid:10966886
52. Udwadia FE, Sunavala JD, Shetye VM, Jain PK. The maximal expiratory flow-volume curve in normal subjects in India. Chest 1986;89:852-6.
http://dx.doi.org/10.1378/chest.89.6.852
PMid:3709250

53. Shore SA, Johnston RA. Obesity and asthma. Pharmacol Ther 2006;110:83-102.
http://dx.doi.org/10.1016/j.pharmthera.2005.10.002
PMid:16297979
54. Jones RL, Nzekwu MM. The effects of body mass index on lung volumes. Chest 2006;130:827-33.

http://dx.doi.org/10.1378/chest.130.3.827
PMid:16963682
55. Watson RA, Pride NB. Postural changes in lung volumes and respiratory resistance in subjects with obesity. J Appl Physiol (1985) 2005;98:512-7.
56. Biring MS, Lewis MI, Liu JT, Mohsenifar Z. Pulmonary physiologic changes of morbid obesity. Am J Med Sci 1999;318:293-7.
http://dx.doi.org/10.1097/00000441-199911000-00002
PMid:10555090
57. Collins LC, Hoberty PD, Walker JF, Fletcher EC, Peiris AN. The effect of body fat distribution on pulmonary function tests. Chest 1995;107:1298-302.
http://dx.doi.org/10.1378/chest.107.5.1298
PMid:7750322
58. Banerjee J, Roy A, Singhamahapatra A, Dey PK, Ghosal A, Das A. Association of Body Mass Index (BMI) with Lung Function Parameters in Non-asthmatics Identified by Spirometric Protocols. J Clin Diagn Res 2014;8:12-4.
http://dx.doi.org/10.7860/jcdr/2014/7306.3993
59. Canoy D, Luben R, Welch A, et al. Abdominal obesity and respiratory function in men and women in the EPIC-Norfolk Study, United Kingdom. Am J Epidemiol 2004;159:1140-9.
http://dx.doi.org/10.1093/aje/kwh155
PMid:15191931
60. Park JE, Chung JH, Lee KH, Shin KC. The effect of body composition on pulmonary function. Tuberc Respir Dis (Seoul) 2012;72:433-40.
http://dx.doi.org/10.4046/trd.2012.72.5.433
PMid:23101008 PMCid:PMC3475466
61. Brashier B, Salvi S. Obesity and asthma: physiological perspective. J Allergy (Cairo) 2013;2013:198068.
http://dx.doi.org/10.1155/2013/198068
62.Lucas SR, Platts-Mills TA. Paediatric asthma and obesity. Paediatr Respir Rev 2006;7:233-8.
http://dx.doi.org/10.1016/j.prrv.2006.08.001
PMid:17098637
63. Shaaban R, Leynaert B, Soussan D, et al. Physical activity and bronchial hyperresponsiveness: European Community Respiratory Health Survey II. Thorax 2007;62:403-10.
http://dx.doi.org/10.1136/thx.2006.068205
PMid:17121869 PMCid:PMC2117184