Original Article

Effect of upper body fat distribution on pulmonary functions in medical students

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ABSTRACT

Background: The prevalence of obesity is increasing, and there is evidence that obesity, in particular abdominal obesity as a marker of insulin resistance, is negatively associated with pulmonary function. The mechanism for this association and the best marker of abdominal adiposity in relation to pulmonary function is not known.

Study objectives: We assessed the association between pulmonary function and body mass index (BMI), waist/hip ratio and Body fat percentage as markers of adiposity and body fat distribution. We used Pearson correlation coefficient to analyse the association of pulmonary function (i.e., FEV1 and FVC) [with manoeuvres performed in the sitting position] with overall adiposity markers (i.e., Body fat percentage and BMI) and abdominal adiposity markers (WHR).

Methods: One forty male subjects underwent physical examination, computerised pulmonary function tests (spirometry, lung volumes) and various anthropometric measurements (waist-hip ratio, BMI, skin fold thickness) out of which seventy were case and seventy were control.

Results: Result showed that expiratory reserve volume and FVC were showed negative correlation with WHR in obese group ($p<0.001$).There was negative correlation observed between BF% and ERV (-0.49), FVC (-0.05), and MVV (-0.11). There was negative correlation observed between BMI and ERV (-0.46) and MVV (-0.17).WHR also showed negative correlation with ERV (-0.14).

Conclusion: ERV and FVC were significantly decreased in subjects with WHR more than 0.93.These results suggest that abdominal adiposity is a better predictor of pulmonary function than Body fat percentage or BMI, and investigators should consider it when investigating the determinants of pulmonary function.

Key Words: Waist Hip Ratio, Body mass index, Body fat percentage, FVC, Abdominal obesity.

INTRODUCTION

An increase in the prevalence of obesity in young adults has been increasingly seen around the world [1]. A variety of anthropometric indices of body distribution have demonstrated that Upper body obesity carries a higher risk of cardiovascular and metabolic disease than does lower body obesity in investigations of severe adiposity [2,3,4]. Although the influence of obesity on pulmonary function tests has been examined [5,6,7], the role of body fat distribution has received limited attention. One widely used measure of determining upper versus lower body fat is the waist-to-hip ratio (WHR), with a WHR of 0.950 or greater indicating upper body obesity and a WHR of less than 0.950 indicating lower body obesity [8]. Preliminary studies of severely obese persons with upper body obesity suggest that they have more severely compromised lung volumes than those with lower body obesity [9,10]. A decrease in lung volume increases respiratory resistance contributing to exercise-induced dyspnoea in obese patients [7]. Abdominal adiposity is a cardiovascular risk factor that is associated with insulin resistance, impaired glucose metabolism, hypertension, and dyslipidemia, all of which are features that are associated with the metabolic syndrome [11,12].

Insulin resistance is recognized as a low-grade inflammatory condition [13,14], and proinflammatory cytokines (i.e. adiponectin, leptin, tumour necrosis factor and interleukin-6) are associated with adiposity [15,19]. Systemic inflammation is also thought to play a role [20,21] in the association between reduced pulmonary function and cardiovascular mortality as well as all-cause mortality [22,23]. However, the exact mechanism for the latter association is not fully understood. Insulin resistance and inflammation that arise from abdominal adiposity may mediate the relation of pulmonary function and all-cause mortality.

MATERIAL AND METHODS

A Study was performed on 140 healthy, otherwise asymptomatic young individuals in the age group of 18 to 24 years, randomly selected from medical students of P.D.U. Medical College, Rajkot. We have selected 70 students having boy fat distribution of 20% or more. To compare with them, we have selected 70 students having body fat distribution of lower than 20%. Individuals doing regular exercise, having respiratory infections or any other respiratory diseases, smokers, hypertensive, or having any musculoskeletal deformities of chest/vertebral column were excluded from the study. Of the subjects, to be enrolled for the study, were informed about the study and procedure details and an informed consent was obtained. The subjects were all healthy asymptomatic.

All participants provided information on age, family history, personal habits (alcohol intake, tobacco consumption, type and level of physical exercise, drug ingestion, known pathological conditions). A detailed physical examination was conducted to exclude cardiac or pulmonary diseases. Our study was reviewed and approved by the Ethics Committee. All the records i.e. anthropometric measurements, skin fold measurements and recording of pulmonary function tests were conducted in one sitting on the same day.

Anthropometric variables like height and weight were obtained. Height was measured to the nearest of 0.1cm and weight was measured to the nearest of 0.1kg with minimum of clothes and no shoes. Body mass index was calculated by Quetelet's Index [24].

The waist circumference (cm) was measured at a point midway between the lower rib and iliac crest, in a horizontal plane. The hip circumference (cm) was measured at the widest girth of the hip. The measurements were recorded to the nearest 0.1 cm.

Skin fold thickness was measured at four standard anatomical sites with the help by measuring skin fold thickness at four sites (4SFT-biceps, triceps, subscapular and suprailiac) with the help of Harpenden's caliper. The percentage of body fat was estimated by using the method of Durnin and Womersley [25].

Pulmonary functions were recorded on a computerized portable lung function unit SP-1. The recorded parameters were compared with the inbuilt pulmonary function norms for the Indian population depending upon the age, sex, height, and weight. Recording of static and dynamic pulmonary function tests was conducted on motivated young healthy volunteers in standing position [26].

These tests were recorded at noon before lunch, as expiratory flow rates are highest at noon. For each volunteer three satisfactory efforts were recorded according to the norms given by American Thoracic Society [27]. The essential parameters obtained were, tidal volume (VT), expiratory reserve volume (ERV), inspiratory capacity (IC), forced vital capacity (FVC), timed vital capacity (FEV1), maximum ventilator volume (MVV) and peak expiratory flow rate (PEFR)

RESULTS

Table 1 shows that expiratory reserve volume and maximum voluntary ventilation were significantly decreased in obese group (p<0.001). In this study there was statistically significant difference in body mass index and waist to hip ratio observed in obese subjects.

Table 1: Comparison of anthropometric parameters of control and obese groups

Parameters	Control (BF<20%) N=70 Mean±SD	Obese (BF>20%) N=70 Mean±SD
Age(years)	19.03±0.24	22.14±0.24
Height(cm)	171.6±0.71	166.3±0.54
Weight(kg)	64.89±1.036	80.09±0.53
BMI(Kg/m^2)	22.07±0.30	29.00±0.20*
WHR	0.83±0.009	0.93±0.007*
Skin fold thickness (mm)		
BICEPS	7.8±0.31	14.6±0.22*
TRICEPS	9.8±0.36	18.7±0.42
SUBSCAPULAR	13.1±0.38	23.14±0.56
SUPRAILIAC	15.31±0.4	27.04±0.68*
Pulmonary function tests		
ERV(L)	1.1±0.041	0.71±0.0079*
IC(L)	3.31±0.018	3.14±0.041
FVC(L)	4.18±0.047	3.74±0.03
FEV_1/FVC	0.7904±0.0025	0.79±0.0024
MVV(L/Min)	127.5±3.56	118.9±1.31*
PEFR (L/Min)	424.9±10.68	445.5±9.38
$FEF_{25-75\%}$(L/Sec)	4.913±0.014	4.919±0.011

*P<0.05 unpaired 't' test;

Body Fat % calculated by Durnin and Womersley method

Table 2 and 3 shows Pearson correlation coefficients in normal (BF<20%) and obese (BF>20%).Body fat percentage showed negative correlation with ERV (-0.43), FVC (-0.20), and MVV (-0.15) in obese subjects and these values were statistically significant. Body mass index also showed negative correlation with ERV(-0.3) and FVC(-0.35).Anthropometric parameters like triceps and suprailiac skin fold thickness showed significant negative correlation with pulmonary function in obese group. WHR which is a marker for abdominal obesity showed significant negative correlation with ERV (-0.78) & FVC (-0.57).

Table: 2: Pearson correlation coefficients in control group (BF < 20%)**

	ERV (L)	FVC (L)	FEV1/ FVC	MVV (L/Mi)	FEF 25-75%
BF%	-0.138	-0.037	0.043	0.019	0.004
BMI (Kg/m2)	-0.334*	-0.183	0.128	0.013	0.071
WHR	0.116	-0.097	0.003	0.024	0.056
Biceps (mm)	-0.148*	-0.085	0.009	0.134	0.092
Triceps (mm)	-0.148	-0.085	0.009	0.134	0.092
Subscapulr (mm)	-0.480*	-0.350*	0.001	0.185	-0.09
Suprailiac (mm)	-0.398*	-0.281*	-0.026	0.038	0.097

(*P<0.05) **n=70

Table 3: Pearson correlation coefficients in obese subjects (BF>20%)**

	ERV(L)	FVC(L)	FEV_1/ FVC	MVV (L/MIN)	FEF 25-75%
BF%	-0.437*	-0.206*	0.206	-0.155*	0.053
BMI (Kg/m^2)	-0.307*	-0.35*	0.167	0.121	0.194
WHR	-0.782*	-0.566*	- 0.224	-0.367*	0.19
Biceps (mm)	-0.072	-0.216	0.281	-0.055	0.096
Triceps (mm)	-0.173	-0.244*	0.337	-0.186	0.116
Subscapular (mm)	-0.193	-0.137	0.105	0.038	0.035
Suprailiac (mm)	-0.20*	-0.053	0.093	0.048	0.043

(*P<0.05) **n=70

Table 4 shows comparisons of pulmonary function tests between the subjects with a WHR <0.93 (n=80) and those with a WHR >0.93 (n=60). FVC & ERV were lower in subjects with a WHR >0.93, p<0.05

Table 4: Spirometry and lung volumes in subjects with a waist to hip ratio WHR≥0.93 compared with those with a WHR<0.93.

Parameters	WHR ≤ 0.93 (n=80)	WHR >0.93 (n=60)
ERV(L)	1.045±0.49	0.73±0.06*
IC(L)	3.329±0.17	3.15±0.34
FVC(L)	5.67±0.41	4.34±0.31*
FEV1/FVC	0.801±0.02	0.79±0.02
MVV(L/Min)	121±32.16	121.7±12.7*
PEFR(L/Min)	428.6±66.15	437.7±95.8
FEF25-75%(L/Sec)	5.15±0.14	4.917±0.089*

(*P<0.05) , unpaired 't' test; Body

DISCUSSION

Abdominal and thoracic fat are likely to have direct effects on the downward movement of diaphragm and on chest wall properties while fat on hips and thighs would be unlikely to have any direct mechanical effect on lungs [28].

In terms of anthropometry, respiratory functions are significantly related to the power of abdominal muscles and upper body fat percentage .In the previous studies, it was shown that pulmonary functions are under the influence of muscularity and fat distribution rather than body weight [29]. Bilgin et al also noted negative correlation between fat% and FVC, MVV, FEV1, and PEF [30].

Sutherland et al observed that FVC was negatively associated with both waist circumference and WHR. FVC and the lung volume parameters (excluding residual volume) were found to have a significant negative association with each of the DXA-derived variables. Strongest correlation was found with FVC [31].

Cheryl et al also observed that abdominal fat (measured by waist circumference, waist to hip ratio and thoracic or upper body fat measured by subscapular skinfold thickness or biceps skin fold thickness) is associated with reduction in lung volumes [28].

Lazarus et al observed that increasing proportions of body fat are associated with decreasing FVC. Wannamethee et al also observed inverse correlation of body fat% with FVC and FEV1 [32]. Lynell c. Collins et al also observed that FVC, FEV1, TLC were significantly decreased in upper body fat distribution (WHR<0.93).They also observed that obesity has inverse relationship with FVC [33]. Joshi et al also observed that central fat distribution is associated with decreased ERV, FVC and MVV [34].

In present study it was observed that subjects with upper body fat accumulation (WHR>0.93) had significantly decreased ERV and FVC, these findings seem to be in perfect tune with previous studies.

CONCLUSION

Significant negative correlation of FVC with body fat percentage has been observed. The observed values of decreased FVC suggested displacement of air by fat within thorax and abdomen.

Waist to hip ratio is highly correlated with abdominal fat mass and is therefore often used as a surrogate marker for abdominal or upper body obesity, In present study central pattern of fat distribution was observed.ERV and FVC were significantly decreased in subjects with WHR more than 0.93. Obese persons with central body fat distribution have more reduced FVC than those with lower body obesity. The intra-abdominal adipose pressing upward on the diaphragm prevents full downward excursion during deep inspiration could be responsible for the results.

REFERENCES

1. WHO. Obesity: preventing and managing the global epidemic: report of a WHO consultation. WHO technical report series; 894. Geneva: The Office of Publication, World Health Organisation, 1999
2. Kissebah AH, Freedman DS and Peiris AN. Health risks of obesity. Med Clin N America 1989; 73:111-38
3. Vague J. The degree of masculine differentiation of obesities: A factor determining predisposition to diabetes, atherosclerosis, gout, and uric calculous disease. Am J Clin Nutr 1956; 4:20-34
4. Kissebah A, Vydelingum N, Murray R, et al. Relation of body fat distribution to metabolic complications of obesity. J ClinEndocrinolMetab 1982; 54:254-60
5. Ray C, Bray G, Hansen J, et al. Effects of obesity on respiratory function. Am Rev Respir Dis 1983; 128:501-6
6. Leech JA, Ghezzo H, Stevens D et al. Respiratory pressures and functions in young adults. Am Rev Respir Dis 1983; 128:17-23
7. Zerah F, Harf A, Perlemuter L, et al. Effects of obesity on respiratory resistance. Chest 1993; 103:1470-6
8. Evans DJ, Hoffman RG, Kalkhoff RK, et al. Relationship of body fat topography to insulin sensitivity and metabolic profiles in premenopausal women. Metab 1984; 33:68-75
9. Enzi G, Baggio B, Vianello A, et al. Respiratory disturbances in visceral obesity. Int J Obes 1990; 14(suppl 2):26
10. Muls E, Vryens C, Michels A, et al. The effects of abdominal fat distribution measured by computed tomography on the respiratory system in non-smoking obese women. Int J Obes 1990; 14(suppl 2):136
11. Sowers JR. Obesity as a cardiovascular risk factor. Am J Med 2003; 115(suppl):37S–41S
12. Reaven GM. Banting lecture 1988: role of insulin resistance in human disease. Diabetes 1988; 37:1595–1607
13. Dandona P, Aljada A, Bandyopadhyay A. Inflammation: the link between insulin resistance, obesity and diabetes. Trends Immunol 2004; 25:4–7
14. Garg R, Tripathy D, Dandona P. Insulin resistance as a proinflammatory state: mechanisms, mediators, and therapeutic interventions. Curr Drug Targets 2003; 4:487–92
15. Kern PA, Ranganathan S, Li C, et al. Adipose tissue tumour necrosis factor and interleukin-6 expression in human obesity and insulin resistance. Am J Physiol Endocrinol Metab 2001;280:E745-51
16. Staiger H, Tschritter O, Machann J, et al. Relationship of serum adiponectin and leptinconcentrations with body fat distribution in humans. Obes Res 2003; 11:368–72
17. Armellini F, Zamboni M, Bosello O. Hormones and body composition in humans: clinical studies. Int J ObesRelatMetabDisord2000;24(suppl):S18–21
18. Gasteyger C, Tremblay A. Metabolic impact of body fat distribution. J Endocrinol Invest 2002; 25:876–83
19. Kern P, DiGregorio G, Lu T, et al. Adiponectin expression from human adipose tissue: relation to obesity, insulin resistance, and tumor necrosis factor-expression. Diabetes 2003; 52:1779–85
20. Sin DD, Man P. Why are patients with chronic obstructive pulmonary disease at increased risk of cardiovascular diseases? The potential role of systemic inflammation in chronic obstructive pulmonary disease. Circulation 2003; 107:1514–9
21. Gan W, Man S, Senthilselvan A, et al. Association between chronic obstructive pulmonary disease and systemic inflammation: a systematic review and meta-analysis. Thorax 2004; 59:574–80
22. Schunemann HJ, Dorn J, Grant BJ, et al. Pulmonary function is a long-term predictor of mortality in the general population: 29-year follow-up of the Buffalo Health Study. Chest 2000; 118:656–64
23. Ryan G, Knuiman MW, Divitini ML, et al. Decline in lung function and mortality: the Busselton Health Study. J Epidemiol Community Health 1999; 53:230–4

24. Garrow JS, Webster J. Quetelet's index as a measure of fatness. Int J Obes 1985; 9(2): 147–53.
25. Durnin JV, Womersley J. Body fat assessed from the body density and its estimation from skinfold thickness measurements on 481 men and women aged 16 to 72 years. Br J Nutr 1974; 32: 77–97
26. Townsend MC. Spirometric forced expiratory volumes measured in standing verses sitting posture. Am Rev Respir Dis 1984; 130(1): 123–4.
27. American thoracic society. Standardization of spirometry. 1994 update Am J Respir&Crit Care Med 1995; 152: 1107–36.
28. Cheryl M. Salome, Physiology of obesity and effects on lung function, JApplPhysiol 2010; 108:206-11.
29. J E Cotes, D J Chinn, J W Reed, Body mass, fat percentage, and fat free mass as reference variables for lung function: effects on terms for age and sex. Thorax 2001; 56:839–44
30. Bilgin, cetin, relation between fat distribution and pulmonary function in triathlets, ovidus university annals, series physical education and support issue 2,suppl.2010
31. T.J.T.Sutherland,A.Goulding,A.M.Grant, The effect of adiposity measured by dual energy X-ray absorptimetry on lung function,EurRespir J 2008;32:85-91.
32. Ross Lazarus, David Sparrow and Scott T. Weiss, Effects of Obesity and Fat Distribution on Ventilatory Function: The Normative Aging Study. Chest 1997; 111; 891-8.
33. Lynell C. Collins, Phillip D. Hoberty, Jerome F. Walker, Eugene C. The Effect of Body Fat Distribution on Pulmonary Function Tests. Chest 1995; 107; 1298-1302
34. Anuradha r. Joshi, ratansingh and a. R. Joshi, correlation of pulmonary function tests with body fat percentage in young individuals, Indian J PhysiolPharmacol 2008; 52 (4) : 383–8

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