Indian J Physiol Pharmacol 2008; 52 (4) : 375–382

EVALUATION OF DYNAMIC FUNCTION TESTS IN NORMAL OBESE INDIVIDUALS

YOGESH SAXENA*, VARTIKA SAXENA**,
JYOTI DVIVEDI* AND R. K. SHARMA*

*Departments of *Physiology and **Community Medicine,*
Himalayan Institute of Medical Sciences,
Jolly Grant, Dehradun – 248 140

(Received on April 4, 2008)

Abstract : The study was undertaken to assess the dynamic pulmonary function tests in obese and non obese young adults of Gharwal (Uttrakhand, India) of 20–40 years age group, randomly selected form the employees of Himalayan institute of medical sciences, attendants of the patients at the hospital and also from the nearby community at Jolly grant, Dehradun. The volunteers representing mixed socioeconomic group were categorized into obese cases and non-obese controls as per the standard criteria for Body mass index (BMI). Dynamic pulmonary function tests were carried out with all the standard protocols. Statistical analysis comprised student's "t" test and linear correlation analysis. The result indicated a significantly lower value of (FVC) forced vital capacity (2.89±0.29) and (FEV1) Forced expiratory volume in 1st sec (2.59±0.25) in obese females. The FVC and FEV1 in the females correlated negatively to the BMI (r = –0.376, P<0.05 and r = –0.359 and P<0.05) and were significant. Dynamic pulmonary function values in males showed a negative correlation but were not statistically significant. This concludes that obesity per se has less effect on the dynamic function tests in obese young adults except in females, but obese individuals presenting with greater morbidity may be more susceptible to altered dynamic pulmonary function test in this age group.

Key words : body mass index (BMI) obesity
pulmonary function test FVC (forced vital capacity)
FEV1 (forced expiratory volume in 1st second)

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, is the increasing prevalence of over weight 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 'the

*Corresponding Author : Dr. Yogesh Saxena, Department of Physiology, Himalayan Institute of Medical Sciences, H.I.H.T. University, Swami Ram Nagar, Dehradun – 248140; Email : drysaxena@rediffmail.com.

abnormal or excessive collection of the fat in the body to the extent that the health is impaired'. Once a nutritional disorder, it has now reached an epidemic proportions even in developing nations. (1) Globally, approximately 1.1 billion adults are over weight, out of which 312 million adults are clinically obese. Recent National Health & Family Survey (NHFS) III (2005–2006) have observed an increase in the prevalence of over weight and obesity in the age group of 18–45 years from total average of 10.6% (1998–99) to 14.4% (2005–06) (1, 2).

Obesity is associated with a variety of medical disorders including the lesser known but not less important respiratory complications viz., airway hyper responsiveness, hypoventilation syndrome and asthma, which can best be appreciated by understanding the obese respiratory physiology (3,4).

Adipose tissue although serves as caloric depots are less metabolic active and muscle work must be performed to move the obese body thereby imposing higher metabolic demands. The same can be reflected by an increased oxygen consumption and increased production of carbon dioxide in obese persons both at rest and during exercise, compromising the cardio respiratory system (5, 6).

There are significant differences in results of pulmonary studies carried out in western world and Asian sub-continent because of significant differences in anthropometric parameters and distribution of fat between Asian and western population. Several Asian studies have asserted the association of respiratory compromise with obesity in people with a lower BMI (operational definition of obesity based on the anthropometric parameters). Therefore the standards based on the Europeans may not indicate morbidity in the Asian group and the values in western population cannot be directly used as predictors for the ethnic Asian origin population (7–10).

The knowledge in this field remains largely incomplete and falls short of making a definitive view in this regard. In above context and paucity of such study in the newly formed state of Uttrakhand, India the study was planned to assess the pulmonary function test in obese young adults, to be conducted at the department of Physiology, Himalayan institute of medical sciences, Dehradun.

METHODS

Eighty healthy volunteers from both the sexes of the age group of 20–40 years were studied during the period of one year. The study group was randomly selected from the employees of Himalayan institute of medical sciences and community dwellers from the surrounding area of Bhaniyawala, Dehradun. Considering the objective of the study the selection was done observing the following criteria–

- Age between 20–40 years.
- Physically and mentally fit.
- Cooperative and capable of understanding the procedure.
- Not suffering from anyknown respiratory and medical problems.

- No acute respiratory illness at the point of entry.
- Non smoker.

After due consent the volunteers were interrogated for the inclusion criteria following strict detailed history with assessment of pulse rate and blood pressure recording as per the Subject Performa. It included the detailed medical history, family history and personal history.

The volunteers were asked to avoid beverages like tea and coffee and other stimulants with light breakfast before reporting at the department of physiology HIMS in the forenoon to avoid diurnal variation in respiratory parameters. They were briefed and familiarized with the procedure to remove apprehension regarding the test. Self demonstration of the required tests was done to help them get conversant with the procedure.

The subjects were enquired for any acute respiratory problem and subjected to anthropometry at the point of entry using the standard procedures and instruments as per the study protocol.

- Age was recorded from birthday by calendar to the nearest of year (<6 months and >6 months).
- Standing height was recorded without shoes and with light cloths on a wall mounted measuring tape to the nearest of centimeters. (<5 mm and >5 mm).
- Weight was recorded without shoes and with light cloths on a Krups weighing machine with a least count of 100 grams.
- Body mass index was calculated by the formula of weight (in kg) and height (in meters). BMI = Weight (kg)/(height in meter)^2.

Pulmonary function test was done by a computerized spirometer (Spiro lab II). The volunteers were asked to take a rest for 5 min –10 min and were briefed with the technique of Forced vital capacity maneuver, with the emphasis on the maximum inhalation followed by maximum exhalation (to be sustained until asked to inhale again). During the whole test procedure they were asked not to allow air to leak from around the mouth piece. The test was carried out in a private and quiet room, in a standing position with the nose clip held in position on the nose. The Flow, Volume/timed graphs were taken out in accordance to the criteria based on the American Thoracic Society (10) and best of the three acceptable curves was selected as the recording. The graphs and values obtained were printed by the spirometer and parameters were noted for analysis. Spirometeric parameters which were recorded for analysis were –

- FVC Forced Vital capacity in Liters
- FEV1 Forced expiratory volume in 1st second in Liters
- FEV1/FVC Ratio of Forced expiratory volume and forced vital capacity in Percentage

Statistical analysis :

Test and control groups were made according to the WHO criteria for relative obesity parameter BMI. A BMI of >/= 30 was taken as obese cases and BMI < 30 as non obese controls (3).

The data were compared using the student's "t" test at the 95% confidence limit. The following comparisons were done: Various parameters of Pulmonary Function Tests in control and test group were compared with independent sample comparison method after stratifying the age in both the genders. Simple linear correlation was carried out to explore the relationship between dynamic pulmonary function tests and BMI. It was followed by Stepwise regression analysis to see the Beta value and its significance between the respiratory variables and BMI.

RESULTS

The mean body mass index of the test group was 33.28±3.39 in males and 33.15±2.73 in females. It was significantly higher than the controls with values of 24.48±1.98 in males and 25.58±3.38 in females within the same age group.

No significant differences in age or height were found among the various groups studied, indicating that the samples were homogeneous in this respect. However, as expected, weight, BMI were significantly different between obese and non-obese groups (Tables I and II). There were no statistically significant differences between non-obese and obese males when we compared FVC, FEV1 and FEV1% values (Table I). Obese females presented significantly lower FVC and FEV1 values than did non-obese females (Table II).

TABLE I: Anthropometric data, body mass index, waist circumference, and pulmonary function values in obese and non-obese males.

Variable	*Non-obese*	*Obese*	*P value*
Age (years)	30.80±6.19	29.4±6.50	NS
Height (m)	1.66±0.09	1.70±6.97	NS
Weight (kg)	68.05±10.04	96.35±6.97	<0.05
BMI (kg/m^2)	24.48±1.98	33.28±3.39	<0.05
FVC (L)	3.75±0.28	3.55±0.36	NS
FEV1 (L)	3.37±0.25	3.80±0.35	NS
FVC/FEV1%	89.63±2.68	89.50±2.47	NS

BMI: body mass index; FEV1: forced expiratory volume in one second; FVC: forced vital capacity; FEV1/FVC: ratio of FEV1 to FVC; NS: not significant, *Significance set at P<0.05; variables expressed in means and standard deviations.

TABLE II: Anthropometric data, body mass index, waist circumference, and pulmonary function values in obese and non-obese females.

Variable	*Non-obese*	*Obese*	*P value*
Age (years)	28.05±5.59	29.65±6.63	NS
Height (m)	1.55±0.04	1.54±0.03	NS
Weight (kg)	54.10±8.18	78.65±7.08	<0.05
BMI (kg/m^2)	22.58±3.38	33.15±2.73	<0.05
FVC (L)	3.19±0.26	2.89±0.29	<0.05
FEV1 (L)	2.88±0.25	2.59±0.25	<0.05
FVC/FEV1%	90.34±3.94	89.73±2.55	NS

BMI: body mass index; FEV1: forced expiratory volume in one second; FVC: forced vital capacity; FEV1/FVC: ratio of FEV1 to FVC; NS: not significant, *Significance set at P<0.05; variables expressed in means and standard deviations.

Correlation bi-variate analysis in males and females, showed a negative correlations between BMI and FVC and FEV1 (Table III). These correlations were statistically significant only in females (Figs. 1 and 2). Step Wise regression analysis (Table IV) showed significant standardized Beta values in both males and females. The significance value in males could be because of the partial correlation being significant for BMI and variables FVC and FEV1.

TABLE III : Correlation between body mass index and spirometric values in males and females.

Variable pair correlation		*P value*
Males	BMI vs. FVC (negative)	NS
	BMI vs. FEV1 (negative)	NS
Females	BMI vs. FVC (negative)	<0.05*
	BMI vs. FEV1 (negative)	<0.05*

BMI : body mass index; WC: waist circumference; NS: not significant FEV1: forced expiratory volume in one second; FVC: (forced vital capacity), *Significance set at P<0.05; negative sign; the higher the BMI, the lower the value of the variable under study.

TABLE IV : Results of step wise regression analysis of variables FVC, FEV1 on BMI, in male and females in age group 20–40 years (y = Constant + Beta X).

Gender	*Standardized beta coefficient on BMI (significance*)*	
	FVC	*FEV1*
Males (n=40)	–0.391 (0.007)*	–0.340 (0.019)*
Females (n=40)	–0.376 (0.017)*	–0.359 (0.023)*

*Significance set at P<0.05.

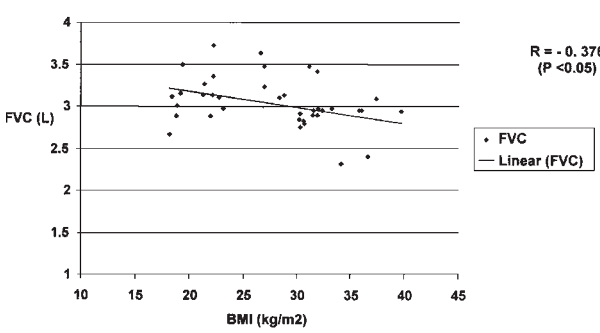

Fig. 1 : Scatter plot showing linear relationship and negative correlation of forced vital capacity and body mass index in females (20–40 yrs) (n=40).

Age wise distribution of dynamic pulmonary function tests in the controls and studied group showed a similar normal

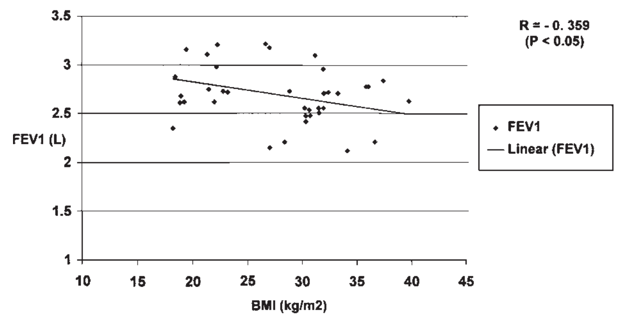

Fig. 2 : Scatter plot showing linear relationship and negative correlation of forced expiratory volume in 1st second and body mass index (kg/m^2) in females (20–40 yrs) (n=40).

decreasing pattern beyond 30 years of age, however the decrease was more in the obese individuals than in non obese in both the sexes. Obese females showed a statistically significant decrease in the values of FVC and FEV1 in the age group of 30 to 40 years. FEV1/FVC did not show a reduction in both the decade of life in both the genders.

DISCUSSION

Among the individuals suffering from obesity, no significant alterations were seen in males, although females presented significant decreases in FVC and FEV1 (Tables I and II). This can be explained by the fact that, obesity aside; women have less respiratory muscle strength and therefore produce lower dynamic compression (12). The hyperventilation caused by the effect of progesterone on the bulbar respiratory neurons, airways, and diaphragm may also explain these alterations (13). Obesity and pregnancy are common causes for reduced FVC since they may interfere with diaphragm movement and chest wall excursion (14). In 1998, Sahebjami (15) studied pulmonary function in 8 healthy obese males and reported spirometric values similar to those found in the present study, although the subjects studied were in a higher age bracket than present study and presented slightly lower BMIs.

Abnormalities in the pulmonary functions of obese individuals have been described for more than 40 years; however there has been considerable variation in the reported degree of alteration, and no definite correlation with body weight or BMI has been shown (16). There are two types of alterations in respiratory function most frequently found in obesity: changes proportional to obesity (reduced ERV and increased diffusion capacity) and alterations exclusive to class III obesity (reduced vital capacity and lower total lung capacity). Although volume restriction is moderate in obesity, vital capacity is inversely proportional to BMI (16–21). Among the obese males, no significant difference was seen in the FVC (3.55L±0.36) as compared to non obese FVC (3.75±0.28), however the values were lower in the obese subjects .Similar results were seen by Zeid et al in their study on Brazilian subjects were the mean FVC value in obese was (5.08±0.59) as compared to (5.14±0.69) in non obese subjects (22). The lower values of the FVC in both the groups in current study as compared to other studies may be attributed to the smaller size of the chest and shorter built of Indian subjects. Study by Lazarus on cohort of men (age 21 to 80 years) found that BMI was negatively associated with FVC but only between the age of 40 and 69 years ($P<0.01$). Lower but significant values of FVC and FEV1 was found in the present study in females. Similar finding were drawn by Zeid et al in their study with the FVC values (mean±SD) in non obese as (3.70±0.52) which was significantly ($P<0.05$) higher than in obese females (3.36±0.56) (22). However, in non-obese individuals, vital capacity is directly proportional to BMI. Consequently, the relationship between vital capacity and BMI (or body weight) in large populations presents an initial increase and a subsequent decrease due to the fact that determination of BMI does not take into account fat distribution within the organism (22). We detected a directly proportional relationship between FVC and BMI in non-obese males and females (control group) in our study, which confirms the data reported by Lazarus et al. (23).

In the present study, no significant correlations were found between BMI and the following spirometric values in male gender: FVC, FEV1, and FEV1/FVC but FVC and FEV1 showed a significantly negative correlation to BMI in females. Various studies have shown altered pulmonary function in individuals with obesity. However, there have been few studies involving obese individuals with lower BMI (24–26). In 1978, Schoenberg et al (24) reported that, due to the related increase in muscle strength, pulmonary function initially increases in parallel with weight gain, although subsequent impairment of chest wall mobility results in reduced pulmonary function. Although several studies have shown that body weight may affect pulmonary function, these data are still in question (24, 25, 27). Due to this muscle effect, higher BMI in young individuals may be accompanied by an increase in pulmonary function. In elderly people, however, due to greater fat deposition, increased BMI is associated with decreased pulmonary function. Consequently, the overall impact of BMI on pulmonary function in population studies may be reduced (27). Most authors agree that weight does not influence spirometric results, or that it does so only in cases of extreme obesity. However, whether weight should be included or not depends on the characteristics of each specific population (24). In the present study, we observed that increased BMI did not impair pulmonary function in males or females with obesity.

Conclusion

The isolated effects of obesity unassociated with other diseases must be identified and the analysis of those effects should be stratified so that obesity related respiratory dysfunction may be evaluated in detail. This aspect is extremely important due to the currently elevated prevalence of obesity and respiratory disease in our society. Although the findings of the present study were inconclusive, they suggest that individuals with obesity and presenting greater morbidity may be more susceptible to alterations in respiratory function due to lower expiratory reserve. The abnormalities found in the spirometric evaluation of individuals with obesity must be attributed to respiratory disease and concomitant obesity.

ACKNOWLEDGEMENTS

Authors are grateful to Himalayan Institute of Medical Sciences for providing facility to conduct this study.

REFERENCES

1. Obesity: Preventing and managing the global epidemic. *WHO Obesity Tech Report Series-894.* Geneva, Switzerland. World health organization; 2000.
2. International Institute for Population Sciences and ORC Marco. National Family Health Survey (NFHSIII), 2005–06: India. International Institute For Population Sciences : Mumbai; 2005.
3. Diet, Nutrition and Prevention of Chronic Diseases. *Report of Joint WHO/FAO Expert Consultation.* Technical Report Series No. 916. World Health Organization: Geneva; 2003.
4. Jeffery S. Flier and Eleftheria Maratos-Flier. Obesity: In Nutrition part 4 Harrison's Principle of internal medicine 16th edi. Editers Dennis L. Kasper, Eugene Braunwald, Anthony S. Fauci, Stephen L. Hauser, Dan L, Longo J, Larry Jameson. Vol. 1 McGraw Hill, Medical Publishing Division, New York, 2005.
5. Silventoinen K, Sans S, Tolonen H, et al. Trends in obesity and energy supply in the WHO MONICA Project. *Int J Obes* 2004; 28: 710–718.
6. Prentice AM, Black AE, Coward WA, Cole TJ. Energy expenditure in overweight and obese adults in affluent societies: an analysis of 319 doubly-labeled water measurements. *Eur J Clin Nutr* 1996; 50: 93–97.
7. Carey IM, Cook DG, Strachan DP. The effects of adiposity and weight change on forced expiratory volume decline in a longitudinal study of adults. *Int J obes Relat Metab Disord* 1999; 23: 979–985.
8. Aggarwal AN, Gupta Dheeraj, Dijgambeheraand, SK Jindal. Applicability of commonly used Caucasian prediction equations for spirometery inter pretation in India. *Indian J Med Res* 122, August 2005, pp. 153–164.
9. Ramchandra A, Snehalatha C, Vishwanathan V, Vishwanathan M, Haffener SM. Risk of non insulin dependent Diabeties Mellitus confere by obesity and central adiposity in different ehenic groups: a comparative analysis between *Asian Indians, Mexican Americans, and Whites. Diabeties Res Clin Pract* 1997; 36: 121–125.
10. Nageshwari K, Sharma R, Kohli DR. Assessment of respiratory and sympathetic cardiovascular parameter in obese school children. *Indian J Physiol Pharmacol* 2007; 51(3): 235–243.

11. American Thoracic Society. Standardization of spirometry. *Am J Respir Crit Care Med* 1995; 152: 1107–1136.

12. Knudson RJ, Lebowitiz MD, Holberg CJ, Burrows B. Changes in the normal expiratory flow-volume curve with growth and aging. *Am Rev Respir Dis* 1983; 127: 725–734.

13. The Gonads. Development and function of Reproduction system. In: William F Ganong *Review of Medical Physiology*. 22nd edition, McGraw Hill Companies, Singapore; 2005; 444.

14. Lean ME, Han TS, Morrison CE. Waist circumference as a measure for indicating need for weight management. *BMJ* 1995; 311: 158–161.

15. Sahebjami H. Dyspnea in obese healthy men. *Chest* 1998; 114: 1373–1377.

16. Bedell GN, Wilson WR, Seebohm PM. Pulmonary function in obese person. *J Clin Invest* 1958; 37: 1049–1060.

17. Ray CS, Sue DY, Bray G, Hansen JE, Wasserman K. Effect of obesity on respiratory function. *Am Rev Respir Dis* 1983; 128: 501–506.

18. Surratt PM, Wilhoit SC, Hsiao HS, Atkinson RL, Rochester DF. Compliance of chest wall in obese subjects. *J Appl Physiol* 1984; 57: 403–407.

19. Rubinstein I, Zamel N, Dubarry L, Hoffstein V. Airflow limitation in morbidly obese subjects nonsmoking men. *Ann Intern Med* 1990; 112: 828–832.

20. Sahebjami H, Gartside PS. Pulmonary function in obese subjects with a normal FEV1/FVC ratio. *Chest* 1996; 110: 1425–1429.

21. Birings MS, Lewis MI, Liu JT, Mohsenifar Z. Pulmonary physiologic changes of morbid obesity. *Am J Med Sci* 1999; 318: 293–297.

22. Zied Rasslan, Roberto Saad Junior (Te Sbpt), Roberto Stirbulov (Te Sbpt), Renato Moraes Alves Fabbri, Carlos Alberto Da Concei O Lima. Evaluation of Pulmonary Function in Class I Obesity and II J Bras Pneumol 2004; 30(6): 508–514.

23. Lazarus R, Gore CJ, Booth M, Owen N. Effects of body composition and fat distribution on ventilator function in adults. *Am J Clin Nutr* 1998; 68: 35–41.

24. Schoenberg JB, Beck GJ, Bouhuys A. Growth and decay pulmonary function in healthy blacks and whites. *Respir Physiol* 1978; 33: 367–393.

25. Chen Y, Home SL, Dosman JA. Body weight and weight gain related to pulmonary function decline in adults: a six year follow up study. *Thorax* 1993; 48: 375–380.

26. Mohamed EI, Maiolo C, Iacopino L, Pepe M, Di Daniele N, De Lorenzo A. The impact of body weight components on forced spirometry in healthy Italians. *Lung* 2002; 180: 149–159.

27. Chinn DJ, Cotes JE, Reed JW. Longitudinal effects of changes in body mass on measurements of ventilatory capacity. *Thorax* 1996; 51: 699–704.