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Research Article

EFFECT OF BODY FAT PERCENTAGE ON EXPIRATORY RESERVE VOLUME (ERV) IN YOUNG INDIAN ADULTS

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ABSTRACT

Background: Obesity impairs quality of life by causing various hazardous effects on respiratory functions of an individual along with other medical complications. The objective of the study was to evaluate effect of body fat percentage on ERV in young adults of Indian population.
Method: 120 students of 18-25 years age group who had no lung disease were recruited. Their age, sex, height, weight was recorded. Students with BMI 18.5- 24.9 kg/m2 constituted control group and students with BMI 25.0 -29.9kg/m2 constituted study group. Skinfold thickness was calculated using 4-site method (biceps, triceps, subscapular and suprailiac) with the help of Skinfold Caliper. Body fat percentage was calculated by using Durnin and Womersley method. ERV was recorded by computerised spirometry. The statistical analysis was done using appropriate tests.
Result: The study group presented with lower values of ERV than control group. Moreover ERV was having strong negative correlation with body fat percentage**.**
Conclusion: The effect of body fat percentage on ERV indicates that obesity affects pulmonary mechanics of an individual.
Keywords: Body fat percentage, Durnin and Womersley method, Expiratory Reserve Volume (ERV).

INTRODUCTION

In the present era of modernization and globalization, developing countries like India is facing obesity as important health problem. Besides the genetic predisposition, adoption of sedentary lifestyle, lack of regular physical exercise, excessive intake of junk foods, stress of competitive world has made the environment conducive to the development of obesity[1]. Most popular index to compare body composition of people and to categorize them as obese and non-obese is the Body mass index(BMI). Although BMI is the major index in evaluating obesity but direct measurement of body fat and its distribution is more important[2]. Moreover the effects of obesity on ventilatory parameters may depend on both the distribution and size of excess adipose tissue[3].The deleterious effects of obesity on pulmonary functions led to various complications. Expiratory reserve Volume (ERV) is the maximum extra volume that can be expired by forceful expiration after the end of a normal tidal expiration. ERV is an important measure of pulmonary function relating to pulmonary mechanics. The current study looks into the association of body fat percentage with ERV in normal weight and overweight M.B.B.S. students. So that the subjects who are at high risk can be identified. This will help to plan and execute preventive measures to prevent negative effects on health and quality of life. Overall the study depicts effect of obesity on pulmonary mechanics of an individual.

MATERIALS AND METHODS

The present study was undertaken in young adults of 18 - 25 years medical undergraduate students from a well known tertiary hospital Mumbai. The proforma and plan of the study were submitted to the local Ethics Committee and were approved before undertaking this study. The plan and purpose of study were explained to students. Then every student signed informed consent. 120 medical undergraduate students of age 18-25 years including both males and females participated in this study. All students were normal without any symptoms. Participants with known history of any respiratory disease, heart disease or major surgery done, any neuromuscular disorder or skeletal muscle abnormalities were excluded.
The study was conducted using equipments: weighing machine, measuring tape, Skinfold Caliper and computerized

PFT machine. Age (years), sex and anthropometric parameters (height (cm) and weight (kg) were noted. Weight was measured using a weighing machine whose least count was 0.5 kg. Height was measured using a measuring scale whose least count was 0.1cm. BMI was then calculated using Quetlet's index as: BMI = weight (kg) / Height (metre) ^{2}

Participants were classified depending upon BMI as:

Control group: 18.5 – 24.9 kg/m^2 and

Study group: 25.0 – 29.9 kg/m^2

In both groups each constituted 60 students having 30 males and 30 females in that individual group. Skinfold measurement method was most widely used body composition testing method for assessing percent body fat. Skinfold parameters measured were biceps (mm), triceps (mm), subscapular (mm) and suprailiac (mm). All these parameters were measured using skinfold caliper (make Anand Agencies) whose least count is 0.1mm. Skinfold caliper is a device which measures skinfold thickness with underlying layer of fat. All measurements were taken on right side of body while standing erect. The participants were instructed to keep shoulder and arm muscles relaxed during the test. All measurements were done on healthy, undamaged, uninfected dry skin. The skinfolds were picked up between the thumb and index finger of left hand and lifted up. The caliper was held in right hand and pressure plates were applied perpendicularly 1 cm above the fingers holding the skinfold tightly and allowing the pressure of the caliper alone to be applied to the skinfold. The reading was taken 2 seconds after the caliper application in mm. The grip was maintained throughout the measurement. Minimum of three measurements were taken at each site with atleast 2 min interval to allow the tissue to restore to its uncompressed form.

Midpoint between tip of acromion process and tip of olecranon process keeping elbow in extended and relaxed position was identified using a measuring tape. At this midpoint vertical fold was raised on anterior aspect of arm for biceps skinfold. For triceps skinfold procedure is same except fold was raised on posterior aspect of arm. Subscapular skinfold measurement was taken on the oblique fold just below the bottom tip of scapula. Suprailiac skinfold measurement was taken on slightly oblique fold just above the crest of ileum in the midaxillary line just towards front from side of waist. The average of three readings at a particular site represented the accepted value for that site. The sum of accepted values at all four sites represented the final skinfold score which was entered into a table given by Durnin and Womersley for calculating body fat percent[4].

The evaluation of expiratory reserve volume was performed by computerized PFT machine manufactured by MEDGRAFICS (CPFS/D USB Med Graphics preVent ™ Pneumotach). The participant was asked to sit comfortably in a chair. Each participant had been explained about the test in detail. They were also shown how to perform the test with sufficient trials. For recording expiratory reserve volume (ERV), the participant was asked to take 3-4 normal breaths then exhale maximally in 3-4 seconds. This procedure gives ERV reading in litres.[5]

RESULTS

The results for ERV and Body Fat Percentage were tabulated. The data entry was done in MS-EXCEL programme and analysis was done by SPSS-IS statistical software version 19.0 for windows.

Table 1: Study variables in comparison between study and Control groups

Parameter	Male		Female	
	Control	Study	Control	Study
Age(years)	19.80±1.79	20.17±1.90	19.37±1.00	19.43±1.30
Height(cm)	170±7.43	163±8.44	159±6.95	158±5.07
Weight(kg)	61.60±6.71	70.72±8.41	53.30±6.65	66.40±5.31
BMI(kg/m^2)	22.52±1.95	26.52±1.09	22.02±1.89	26.18±0.74

Table 2: Comparison of skinfoldthickness(4-sites in mm),Body Fat % and ERV between control & study groups

	Male		Female	
Parameter	Control	Study	Control	Study
Biceps	9.77±1.17	11.30±2.00	13.10±2.09	19.53±1.50
Triceps	11.23±1.55	15.50±2.10	14.30±2.29	21.60±1.60
Subscapular	11.20±1.32	15.57±2.50	16.37±4.41	23.17±2.20
Suprailiac	12.30±1.84	17.30±2.58	17.37±4.60	24.67±3.47
Body fat%	17.43±1.21	21.42±1.70	29.08±3.03	34.40±3.05
ERV (L)	1.46±0.19	1.21±0.21	1.04±0.08	0.82±0.04

For statistical analysis, the data were submitted to 'unpaired t 'test. So that comparison of ERV in study and control group was obtained. Compared data was expressed as Mean ± SD. Statistical significance was indicated by 'P' value < 0.05. For finding correlation between body fat percentage and ERV, Pearson's correlation test was applied.

Table 3: Correlation of Body Fat %with ERV in males and females

Body fat percentage		PFT-ERV
Female (60)	Pearson Correlation	-0.639
	Sig. (2-tailed)	3.81E-08
Male (60)	Pearson Correlation	- 0.633
	Sig. (2-tailed)	5.80E-08

DISCUSSION

Quantitative distribution of body mass provides the initial framework for the description of man's nutritional status[6].The fat content of the human body influences morbidity and mortality of individuals. Expiratory reserve Volume (ERV) is the maximum extra volume that can be expired by forceful expiration after the end of a normal tidal expiration. A significant negative correlation of ERV with body fat percentage in males (r= -0.63) and females (r= -0.63) was found. This indicates that ERV diminishes in inverse proportion to body fat percentage. This may be due to shift in the balance of inflationary and deflationary pressures on the lung due to the mass load of adipose tissue around rib cage and abdomen and in the visceral cavity[7] Expiratory reserve volume (ERV) has been consistently identified as the most severely affected, typically depressed variable of pulmonary function in obesity [8]. A distinctly restrictive respiratory pattern is identified in obese. The mechanisms responsible for the restrictive pattern seen in obesity relate to impedance of pulmonary mechanics.

Coates, Chinn and Reed in their study of body mass, fat percentage and fat free mass as reference variables for lung function in 2001 stated that fat percentage contributed to RV and ERV and hence to FRC, VC and TLC all with negative sign, suggesting displacement of air by fat within thorax and abdomen [9.] Fat can be laid down in the mediastinum, around the heart, pleural space and above the diaphragm. In any of these positions it occupies space that would otherwise be available for alveolar air. Similarly, in the abdomen, fat can accumulate round the kidneys, other organs and in the mesentery. Additional fat reduces the functional residual capacity both directly by its presence in the thorax and indirectly by raising the diaphragm[10].

Respiratory compliance is the ability of the respiratory system to stretch during a change in volume relative to an applied change in pressure [10.] Obesity is characterized by combination of effects on lung and chest wall compliance[11, 12]. Lung compliance is decreased due to reduced distensibility of extrapulmonary structures, increased pulmonary blood volume, closure of dependent airways and increased alveolar surface tension[11, 12, 13] .The increased adiposity around ribs, diaphragm and abdomen leading to limited movement of ribs as well as decreased total thoracic and pulmonary volume pulling chest wall below its testing level cause reduction in chest wall compliance[14].

Hedensteierna G. and Santesson J. in 1976 studied breathing mechanics and gas exchange in 10 extremely obese subjects (average weight 138 kg) prior to and during anesthesia with mechanical ventilation. They found that lung compliance during spontaneous breathing was below normal and decreased further during artificial ventilation. Chest wall compliance measured during anesthesia was within normal limits. Lung resistance was above normal during spontaneous breathing and increased further during mechanical ventilation[13]. Pelosi and colleagues in 1998 studied the effects of body mass on lung volumes, respiratory mechanics and gas exchange during general anesthesia. They found that with increasing BMI i) FRC decreased exponentially ii) the compliance of total respiratory system and of the lung decreased exponentially [14].

The impaired respiratory muscle function has been possibly related to fatty deposits, overstretched diaphragm, decreased isokinetic skeletal muscle endurance[15, 16, 17, 18,19,20,21]. Reduced respiratory muscle strength and endurance, as suggested by static maximal inspiratory pressure values of 60-70% of normal subjects, have been described among three severely obese subjects with obesityhypoventilation syndrome in a 1974 study by Rochester and Enson [18, 22]. Chlif, Keochkerian and colleagues in their study in 2005 investigated the effect of excessive mechanical load caused by obesity on the inspiratory muscle performance in obese men at rest**.** They concluded that excessive mechanical load caused by obesity imposes a great burden on the inspiratory muscle which may predispose such subjects to respiratory muscle weakness at rest [23]. The deposition of fat in mediastinum reduces the space available for air. Increased adiposity around ribs, diaphragm and abdomen leads to limited movement of ribs. All these factors can lead to squeezing of the lungs.

Thus all the above causes that lead ERV to be the most severely, consistently affected, typically depressed variable of pulmonary function in obesity can be listed as:

1. Displacement of air by fat within thorax and abdomen.
2. Physical restriction of diaphragmatic function by abdominal contents impairment.
3. Diminished chest wall and total respiratory system compliance secondary to increased chest wall fat.
4. Impaired respiratory muscle strength.
5. Squeezing of the lungs due to added weight of the chest wall.

CONCLUSION

The findings of study indicate that measure of body fat percentage affects lung volumes which are evidenced by changes in ERV in overweight adults. But these changes were not significantly causing obstructive or restrictive disorder in overweight adults. Thus obesity affects pulmonary mechanics of an individual. Limitation of study is measurement of inspiratory and expiratory pressures at different lung volumes. Although many studies regarding effect of obesity on pulmonary functions have been done from time to time, still we have not succeeded in bringing about curative measures. So the main importance now lies in identifying subjects at risk as means of preventive measures.

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