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Original Article

Some Aspects of Pulmonary Functions in the Underweight and Overweight Human Subjects

D. V. Muralidhara* and M. Ramesh Bhat†

ABSTRACT **Several factors such as respiratory muscle strength, lung compliance, resistance to airflow etc., affect the lung functions. Studies on pulmonary functions in relation to body composition are lacking. We hypothesized that lung functions both in the obese and the undernourished subjects would be reduced due to mechanical disadvantages. Therefore, the present study was designed with the aim to compare some aspects of lung functions in humans with varying body fat content and fat free mass. A large number of young college students of both sexes included in the study were classified into normal (N), undernourished (UN) and overweight (OW) groups based on their body mass index (BMI). Body fat (BF) and lean body mass (LBM) were estimated in each subject using Futrex -5000 A. The body fat varied from 13% to 25% in male subjects and 26% to 35% in females as BMI increased. Male subjects with low BMI had 87% LBM while those with normal and high BMI had 80% and 75% respectively. Correspondingly, females had lower LBM values of 73%, 69% and 65% as the BMI increased. Interestingly, absolute values of LBM content increased in subjects of both sexes with increments in BMI. Pulmonary functions including , forced vital capacity (FVC), forced expiratory volume in the first one second (FEV1) and peak expiratory flow rate (PEFR) were also assessed by using Morgan's spirocheck. Data was analysed using ANOVA and unpaired t test for statistical significance of differences. The relationship between lung functions, BMI, BF and LBM was not significantly different from one another either in the male or female groups except for differences between the genders. FVC was about 3.7 L, FEV1% was about 80% and PEFR was about 375 L/min in male subjects while the females recorded significantly lower values.**

Key words: **FVC, FEV1, PEFR, Body fat, Lean body mass**

INTRODUCTION

Both physiological and pathological factors affect lung functions[1,11,12,13,14,18,20,22,23]. Pulmonary functions are generally determined by respiratory muscle strength, compliance of the lung and thoracic cavity, airway resistance and elastic recoil of the lungs[5]. Furthermore, the stature (height), body weight and body build of an individual can also affect pulmonary functions[19].

Human beings can be grouped into normal (N), undernourished (UN)/ or underweight (UW) and overweight (OW)/ or obese (Ob) individuals on the basis of body mass index (BMI) or Broka's index[10,25]. Excess body weight in an obese or overweight person is normally due to accumulation of extra body fat[26], while in undernutrition; depletion of body resources of proteins and calories is associated with wasting of skeletal muscles, including respiratory muscles[12]. It was hypothesized that lung functions in the obese individuals would be lower, as the extra fat would exert a mechanical effect on the

* *Uni-KL Royal College of Medicine Perak, Ipoh Malaysia*
† *Department of Physiology, Kasturba Medical College, Mangalore - 575 001, India*
Address for correspondence:
Dr DV Muralidhara, PhD
Uni-KL Royal College of Medicine, #3, Jln Greentown 30450, Ipoh, Perak State, Malaysia Email: diviem@yahoo.com

movement of chest or abdomen, while in the undernourished, the lower absolute lean body mass that may cause poor respiratory muscle strength, may result in reduced lung functions. Therefore, the present work was undertaken to establish the relationship between lung functions and body composition in young underweight or overweight men and women with different body fat (BF) and lean body mass (LBM) since such studies on Indian subjects are lacking.

MATERIALS AND METHODS

Physical characteristics:

Two hundred and sixteen healthy, normal students (Male-116, Female-100) from the Kasturba Medical College, Mangalore, aged between 18 and 22 years were recruited for this study. Clearance from the Ethic's committee of the institution was obtained before starting the study. Prior informed consent was also obtained from each subject and there was a briefing session of the project with them. Subjects with any apparent health problems of respiratory system or physical disabilities were not included in the study. Data on physical characteristics such as body weight and height were collected along with other measurements for body composition from each participant. Body mass index (BMI-kg/m^2) and waist-hip ratio (WHR) were also calculated[10,3].

Based on BMI, male and female subjects were grouped separately according to WHO recommendations[26]. However, since there were few subjects in extreme underweight and overweight groups, we considered having only three groups namely, normal (N), (BMI; 18.5-25); underweight (UW), (BMI < 18.49); and overweight (OW), (BMI > 25) for the present study.

Body fat and Lean body mass assessment using Futrex 5000-A: -

Total body fat (TBF) and lean body mass (LBM)/ fat free mass (FFM) were assessed with the help of an electronic body composition and fitness analyser (Futrex 5000-A, Futrex Inc, Gaithersburg, MD 20879, USA). The equipment was calibrated to provide accurate body fat readings to hydrostatic measurements.

Futrex 5000-A utilizes Near Infrared-light Interactance (NIRI) principle. The optical measurements were made at NIRI wavelength of 940 - 950 nm, which provide a direct measure of TBF and Total Body Water (TBW). LBM was calculated as the difference between body weight and body fat. Data on age, sex, height, body frame, physical activity rating of each subject was fed into the machine. The light wand (important component of the equipment) was placed on right biceps at midpoint between anterior cubital fossa and acromion for measuring fat content. The other part of the operating procedure was carried out by pressing keys on the instrument as explained in the user manual.

Assessment of lung functions:

Lung functions were assessed in each individual in standing posture by using a digital spirometer (Morgan's Spirocheck, PK Morgan Ltd, Kent, UK). This included forced vital capacity (FVC) in liters, forced expiratory volume in the first one second (FEV1) in liters and peak expiratory flow rate (PEFR) in liters per minute. FEV1 percent was calculated as FEV1 divided by FVC multiplied by 100. Lung functions were recorded in accordance with the standard recommendations. The readings were corrected for BTPS.

Statistics:

Data on body composition and lung functions are presented both in percent and absolute values. Results were compared in each gender across groups by using ANOVA test and between similar subgroups of male and female subjects by using unpaired t test for statistical significant differences. The level of significance for all statistical tests was set at 0.05. All values given are mean ± SEM.

RESULTS

Table 1 summarizes the physical characteristics of the subjects in different groups. The average age of the subjects was about 18.7 years. Body weight varied from 53 to 77 kg in males and 45 to 67 kg in females. Body fat (kg or percent) was obviously different for the two genders and their subgroups. There were no obese subjects. LBM percentage varied inversely with body fat percent values. Though WHR was within normal limits for each sex group, the overweight male (group III) had higher values than the other groups. Table 2 shows further details.

Differences in FVC, FEV1 and PEFR were not significant across groups either in the male or female sub-

Table 1 Physical Characteristics of male and female subjects. (Values are Mean (SEM)

Variable	Gender MALE			FEMALE		
	Group I	II	III	I	II	III
	BMI <18.49	(18.5-25)	>25	<18.49	(18.5-25)	>25
Age (Yrs)	18.62 ± 0.80	18.82 ± 0.80	19.00 ± 1.00	18.52 ± 0.71	18.77 ± 0.79	18.70 ± 0.68
Body Weight (Kg)	53.46 ± 6.26 *	64.89 ± 6.52 *	77.20 ± 5.72 *	45.22 ± 3.79 *†	53.86 ± 6.19 *†	66.85 ± 5.96 *†
Height (cm)	176.85 ± 9.87	176.01 ± 6.72	171.80 ± 8.08	161.00 ± 5.62†	159.90 ± 6.81†	158.8 ± 4.85†
BMI (Kg/m2)	17.08 ± 0.99*	20.99 ± 1.71*	26.16 ± 0.81*	17.26 ± 0.94 *	20.99 ± 1.73 *	26.48 ± 1.76 *
WHR	0.80 ± 0.14	0.84 ± 0.12	0.88 ± 0.02 *	0.73 ± 0.05†	0.76 ± 0.08	0.78 ± 0.04
n	26	85	5	25	65	10

'n' = number of subjects, BMI= body mass index, WHR=waist hip ratio

*: *P*< 0.05 across groups, †*P*< 0.05 across gender

Table 2 Body composition (BC) in % and Kg and lung functions (LF) in male and female subjects. (Values are Mean (SEM)

Variable	Gender MALE			FEMALE		
	Group I	II	III	I	II	III
	BMI <18.49	18.5-25	>25	<18.49	18.5-25	>25
	n (26)	(85)	(5)	(25)	(65)	(10)
BC:						
TBF (%)	12.85 ± 4.25	19.0 ± 4.24 *	25.18 ± 2.77 *	25.95 ± 2.53*†	30.56 ± 2.31*†	34.75 ± 2.97 *†
TBF (kg)	6.76 ± 2.10	12.71 ± 4.51*	19.32 ± 1.08*	11.74 ± 1.56*†	16.40 ± 2.67*†	23.26 ± 2.97*†
LBM (%)	87.15 ± 4.25	79.57 ± 9.68 *	74.82 ± 2.77 *	73.25 ± 4.80 *†	69.44 ± 2.31*†	65.25 ± 2.97 *†
LBM (Kg)	46.69 ± 6.00	52.52 ± 5.41*	57.88 ± 6.25 *	33.47 ± 2.94*†	37.13 ± 5.21*†	43.70 ± 4.25*†
LF:						
FVC (L)	3.69 + 0.65	3.83 ± 0.72	3.69 ± 0.68	2.67 ± 0.48*	2.76 ± 0.49*	2.76 ± 0.48*
FEV1 (L)	3.13 ± 0.49	3.15 ± 0.49	2.95 ± 0.57	2.20 ± 0.33 *	2.36 ± 0.40 *	2.23 ± 0.30 *
PEFR(L/min)	376.27 ± 106.40	374.38 ± 78.36	374.40 ± 105.88	256.76 ± 53.12*	276.97 ± 99.76*	254.20 ± 56.23*
FEV1(%)	85.09	82.24	79.95	82.39	85.50	80.43

TBF: Total body fat; LBM : Lean body mass ;

Only mean values of FEV1 (%) are shown; FVC=Forced vital capacity; FEV1=Forced expiratory volume at the end of first second;

PEFR=Peak expiratory flow rate; L=liters, * : *P*< 0.05 across groups †: *P*< 0.05 across gender.

jects. However, significant differences were evident when the values were compared between similar subgroups of males and females. The calculated percent values for FEV1 are also given in Table 2.

DISCUSSION

Several factors affect lung functions[27]. Earlier studies available have reported the relationship between lung functions and body weight, height and body mass index [9,19,21]. Several indices such as the BMI, body weight or height by themselves have limitations in interpreting the results. Moreover, the importance of BMI in several situations is also questioned. Therefore, it is necessary to measure the components of the body mass (at least, the body fat and lean body mass/fat free mass; the two major components contributing to body weight) and relate the lung functions, since both can influence lung functions.

All the dynamic functions of the lung depend upon the compliance of the thorax-lung system, airway resistance and muscular strength of the respiratory muscles[5,13]. The primary factors that affect PEFR are the strength of the expiratory muscles or the force of contraction, the elastic recoil pressure of the lung and the airway size[11]. A decrease in FVC, FEV1 and PEFR could be attributed to disease conditions in the bronchial passages associated with damage to the elastic component of the alveolar walls and decrease in the contraction of the chest cavity[6,22]. However, FEV1 and PEFR may not be the most suitable variable to detect the early deterioration of the ventilatory functions[2,17]. Similarly, increases in ventilatory functions may be seen in individuals who are on some forms of regular exercise like swimming[14]. The causes for such increases are probably increase in lung inspiratory capacity, elasticity of the lung, chest wall and ventilatory muscles and increase in lung weight in some cases[14].

With better nutritional status of the individual and good exercise habits, there will be better growth of skeletal muscle system of the thorax and lung tissue resulting in improved lung function[18]. There are reports that claim a good correlation between fat free mass and lung functions during a weight loss programme in obese people[7,24]. An increase in muscle mass may partly explain the association between FVC and LBM/FFM given that the muscle mass is part of the LBM/FFM. Extra fat deposits can have mechanical effect on ventilatory functions. Large amount of abdominal fat mass may impede descent of the diaphragm during inspiration. A thorax with a large amount of subcutaneous fat over the chest may lead to a change in the balance between the elastic recoil of chest wall and lung-chest wall compliance[15]. Increase in body weight in the initial stages may increase lung functions due to an effect of muscularity and a later increase in body weight would reduce the lung functions due to an obesity effect[8]. Though, significant differences were present in body fat content and fat free mass in the subjects of the present study, it did not influence their lung functions. Since BMI of the underweight our overweight groups is not so overt and the subjects were quite young, high motivation and enthusiasm may have overcome the deficits, even it had existed.

It is also mentioned that WHR inversely affects the static lung function[4] i.e. a low WHR indicative of lower abdominal body fat distribution and a high WHR indicating fat distribution showing high and low lung functions, respectively. Though, the overweight male and underweight females had significantly different WHR as compared with the other groups, it did not influence their lung functions significantly. This may be due to the differences were small and the WHR values were within the normal limits for the respective gender groups. WHR values of 1.0 and 0.8 in male and females respectively, are indicative of abdominal obesity.

It may thus be concluded that, the young subjects of the present study, who were different by their body mass index, body fat and fat free mass, did not show significant differences in lung functions. These results thus confirm the findings of another report on the effects of extra body fat on maximal inspiratory pressure (MIPS) and maximum expiratory pressure (MEPS) generally referred to as Pmax, in young overweight and obese women with a BMI up to 40 kg/m^2 who were around 20 years of age[16]. Therefore, the hypothesis, that obese subjects and undernourished subjects may have reduced lung functions is rejected. It may be because of the differences in body composition in such groups were not sufficient enough to induce changes in lung functions. Or, even though the differences existed, it may not be detectable in the young subjects[2,17].

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