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Correlation of Static Lung Function with Fat Free Mass & Fat Free Mass Index

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Abstract

Static Lung Functions: besides physiological measurements, help in the diagnosis of underlying lung disease. It can be used to determine the severity of respiratory muscle involvement in neuromuscular disease, and can guide treatment decisions in several diseases too. This is a pioneering study to assess the correlation of fat free mass index(FFMI) with the static lung function instead of Body Mass Index(BMI). BMI can be misleading as it does not distinguish between the fat & muscle compartment. So, the aim of our study is to establish that FFMI should be used as reference variable for assessment of static lung functions rather than BMI.

Keywords: Static Lung Function; Fat Free Mass; Fat Free Mass Index; Body Mass Index.

Introduction

The belief, that weight shows little or no correlation with pulmonary function measurements [1], has been abandoned and Body Mass Index (BMI) is used as reference variable for various lung functions. Several studies have shown that elevated BMI is associated with impaired Pulmonary Function Parameters [2]. But BMI has limitation of not distinguishing between Body Fat & Body Fat Free Mass (FFM) [3]. Fat free mass includes muscle, bone, water & blood. Fat percentage is independent of stature and FFM resembles body mass as it is correlated with stature. The association is reduced or eliminated by expressing FFM as Fat Free Mass Index (FFMI).

$$FFMI = FFM / Stature^2$$

Measurement of static lung function, provide detail information regarding the functional status of lung & are determined by the elastic properties of lung. The result is used as an aid to diagnosis, for monitoring the progression of disease, or for the evaluation of therapy. Effect of obesity on respiratory function [2,4,5] has been established in various previous studies. This study is undertaken to assess if correlation of PFT exists with body fat percentage, FFM, FFMI and whether it is possible to establish them as lung reference variable.

Methods

The study was conducted on apparently healthy 150 medical students (85 males, 65 females) aged between 17 and 24 years. The experimental protocol was explained and written. Informed consent was obtained from all the volunteers. The Institutional Ethical Committee has approved the study, conducted between October 2010 and August, 2012. The subjects with history of smoking, asthma, any other past/ concurrent pulmonary diseases, and any other systemic diseases were excluded from the study. The study was conducted after 2 hours of light breakfast. To avoid circadian variation [6,7] all study were conducted between 10 am to 12 noon.

All anthropometric measurements such as age, sex, height and weight were recorded. Body weight was recorded in kilograms on empty bladder and wearing light weight clothing and bare foot with “Prestige Digital Weighing Scale”. Standing height was recorded using “stadiometer” to the nearest 0.1cm. Waist circumference and Hip circumference were measured using measuring tape. Waist by hip ratio

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was calculated. BMI was calculated using Quetlet's Index[8]-BMI=Weight (in kg) / {Height(in meters)}^{2}

The body fat percentage was measured by "Bioelectric Impedance" analysis technique using 'OMRON Body Fat Monitor (HBF-306)'. Now FFM (100-Fat% × body weight) and FFMI (FFM / Ht^2) was calculated.

Pulmonary Function were recorded, on a window based "Flowhandy ZaN 100 USB & ZaN. GPI. 3xx", Germany, according to American Thoracic Society Guidelines [9].

Results

Observed finding are depicted in the Tables (1-4) and diagram (1-2).

Distribution According to Gender

Out of 150 subjects, 85 are males(57%) and 65 are females(43%) as depicted in Diagram → 1

Only BMI was found to be homogenous in both males and females. This is also depicted in the bar diagram in Diagram → 2.

Analysis was done using GraphPad Prism 6.0. Unpaired t-test, correlation and linear regression equation was used for the analysis.

The static lung values were found to be significantly different on Unpaired t-test.So, the male and female lung functions were compared separately with their respective body composition to avoid gender related variations.

Table 3 shows the various correlation coefficients of all the obesity markers like, BMI, BF%, Waist to hip ratio and muscularity or fitness markers like, FFM and FFMI and they are correlated with each static lung functions of males individually. This table shows that FFM followed by FFMI has highest correlation coefficients for all Static lung values except ERV which has highest significant negative correlation coefficient with BF%. BMI though significant but does not have highest correlation coefficient for any static lung function.

TV does not have significant relationship with any of the parameters.ERV has significant negative relationship with all body composition parameters except for FFM and W / H which does not have any significant correlation. ERV has highest negative correlation coefficient with BF% and BMI. IRV & IC has highest significant 'Pearson R' value for FFM followed by FFMI, Waist and Hip ratio, though all parameters have significant correlation with IRV and IC, but IC has insignificant correlation with W / H ratio. VC has significant positive correlation with FFM, whereas insignificant relation exists with all other parameters.

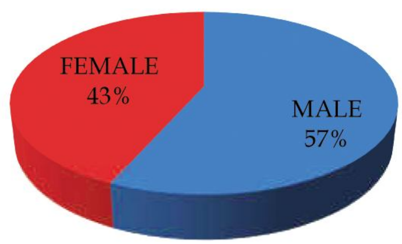

Diagram 1

Table 1: Anthropometric parameters (Mean ± SD)

	Males	Females
HEIGHT(In cm)	165.55 ± 5.8608	154.1158 ± 6.109
WEIGHT(In kg)	64.706 ± 11.7838	56.8153 ± 11.387
WAIST CIR(In inches)	31.846 ± 2.9081	30.118 ± 4.147
HIP CIR.(In inches)	36.984 ± 2.629	35.781 ± 3.853
WAIST / HIP RATIO	0.8606 ± 0.04819	0.841 ± 0.061
BMI (kg / m^2)	23.5108 ± 3.7207	23.9015 ± 4.4875
BF%	22.946 ± 5.1178	31.14 ± 6.125
FFM (kg)	49.4012 ± 6.7735	38.481 ± 4.816
FFMI (kg / m^2)	17.984 ± 1.9372	16.1866 ± 1.657

Diagram 2

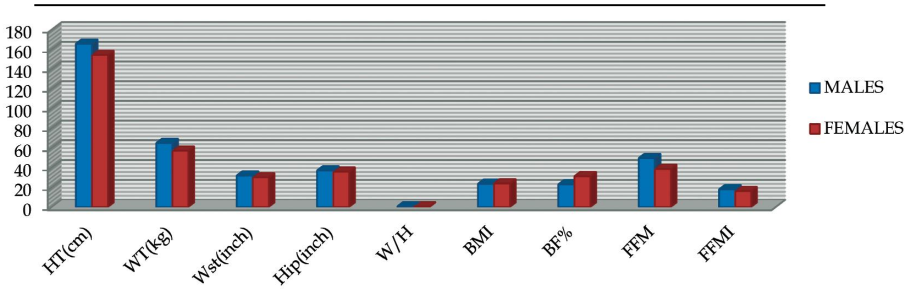

Table 2:

	Males	Females	p-value(Unpaired t)
ERV (In litres)	1.14837 ± 0.398798	0.833846 ± 0.311861	< 0.0001
IRV (In litres)	2.323587 ± 0.48605	1.691692 ± 0.357657	< 0.0001
TV (In litres)	0.578152 ± 0.291529	0.481231 ± 0.207539	< 0.0001
IC (In litres)	2.902065 ± 0.544876	2.172769 ± 0.370976	0.0236
VC (In litres)	4.047609 ± 0.528543	3.006769 ± 0.423142	< 0.0001

(P < 0.05→significant)

Table 3: Correlation coefficients/pearson R (males)

	BMI	BF%	FFM	FFMI	WHR
VC	0.2483	0.1144	0.5789	0.3289	0.2665
TV	0.2758	0.1830	0.3074	0.2412	0.06207
ERV	-0.4775	-0.4960	-0.1703	-0.3574	-0.1689
IC	0.6021	0.4853	0.6891	0.5884	0.3792
IRV	0.5131	0.4366	0.5913	0.5185	0.3889

(All the values in bold are significant values, i.e. p <0.05)

Table 4: Correlation coefficients (females)

	BMI	BF%	FFM	FFMI	W/H
VC	0.03225	0.04842	0.4491	0.06648	0.1034
TV	0.06460	0.1292	0.05422	0.002313	0.1449
ERV	-0.3698	-0.3697	-0.05877	-0.3109	-0.03205
IC	0.3477	0.3664	0.5614	0.3364	0.1449
IRV	0.3217	0.3040	0.5472	0.3464	0.07816

(All the figures in bold letters are Significant, i.e. p<0.05)

Discussion

Anthropometric Parameters: Table à1,Diagram à1&2 In our study on 150 subjects out of which 85 were males and 65(43%) were females. We have studied young healthy (17-24 years) subjects for the study. The number of volunteers studied was quite high compared to many workers. Lynell C & Phillip D (1995) [10] had conducted their study on 44 firefighters. Anuradha R et al, 2008 [11] studied on 132 males and females overweight students of age group 18-21 years. But here we have taken subjects of random stature irrespective of their BMI and body weight. Ceylan and co-workers, 2008 [12] studied only 53 volunteers. Lorenzo and co workers,2001 [13] studied on 30 obese adults.

Lorenzo and co workers, 2001 [13] and Anuradha R et al, 2008 [11] studied on obese adults. Nicholas S H and co-workers, 2007 [14] studied on 64 patients with stable COPD. Whereas we have studied healthy adults having BMI within normal range.

Mean Static Lung Function Tests

The male and female lung functions were compared separately with their respective body compositions to avoid gender related variations.Our views agree with the studies by Cotes et al [15], Hibert et al [16], Rosenthal et al [17] and Gibson et al [18].

Static Lung Function in Males

The correlation of ERV agrees with the findings of Anuradha R et al 2008 [11], Ceylan and co-workers, 2008 [12] and Cotes et al (2001) [19]. They have discovered negative correlation of ERV with BF%. This proves the explanation that increased fat percentage in body leads to displacement of air by fat within thorax and abdomen [19].

But Contrary to the finding of Anuradha R et al 2008 [11], Ceylan and co-workers, 2008 [12] and Cotes et al (2001) [19] VC does not have negative correlation with BF%. Instead BF% does not have significant correlation with VC. But since VC can be increased with effort, it relates very significantly with Fat Free Mass (FFM) which coincides with the findings of Lorenzo and coworkers [13] and Ceylan and co-workers, 2008 [12] that loss of Fat Mass improves VC and Fat Free Mass has positive correlation with VC.

Waist and hip circumference showed positive correlation with all static parameters except ERV, which does not agree with the finding of Lorenzo and coworkers [13], Heather and co-workers, 1990 [20], Enzi et al,1990 [21] and Muls et al,1990 [22]. It may be because we have taken young adults with normal BMI contrary to obese subjects taken for study by the others.

FFMI had shown significant contribution towards IC as seen in study by Cotes et al, 2001 [19]. Our study shows the same but here FFM is found to have most significant correlation factor followed by FFMI.

IRV and TV have not been studied much. Anuradha R et al, 2008 [11] had found no correlation with BF%. In our study we have also found TV has no significant correlation with BF%. But all these static lung values are effort dependent and their positive correlation with FFM proves the same.

Ray and co-workers, 1983 [4], Francoise and co-workers, 1993 [23] and Jones and Mary Magdalene, 2006 [2] observed that ERV and VC dropped significantly as BMI increased.

Static Lung Function in Females

Our study agrees with the study of Jones and Mary Magdalene, 2006 [2], Ray and co-workers, 1983 [4], Anuradha R et al, 2008 [11], andCeylan and co-workers, 2008 [12],where ERV had negative correlation with BF% and BMI , in females. But Ray and co-workers, 1983 [4] and Jones and Mary Magdalene, 2006 [2]observed that more increase in BMI will only lead to deterioration of lung functions like VC. W/H ratio was negatively correlated with static functions which is not the case in our study. This may be because we have not taken overtly obese girls for our study.

IC and IRV are not much studied in females, where we have found highly significant positive correlation with FFM which shows that, decline in fat free mass is associated with worsening of lung function [24].

Hence, neither BMI nor waist hip ratio can be considered as a reference variable. But BF% and Fat Free Mass (FFM) and Fat Free Mass Index (FFMI) can be considered as a consistent reference variable for static lung functions.

These observations show that changes in both fat and muscle can affect lungs; however, they can have opposite effect on VC and other indices so that when together considered as mass they can cancel each other out [19].

Conclusion

Static lung parameters have highest significant positive correlation with Fat Free Mass and Fat Free Mass Index, except ERV which has highest and significant negative correlation with Body Fat % in both males and females.

This study supports the view of the studies that respiratory muscle strength has effect on respiratory function [25,26]. As FFM & FFMI are direct assessment of muscle amount, so, increasing FFM by various exercises may prove to be useful in improving respiratory function rather than just losing weight.

Making allowances for body composition can improve the accuracy and biological relevance of reference equation for lung function [5]. The use of anthropometric and skinfold measurements has been criticised as being unreliable and inaccurate; they are unable to adequately assess adiposity and are liable to operator bias [27]. Limited usefulness of BMI should be taken into consideration and FFM & FFMI should be used as reference variable. Measurement of FFM by 'Bioelectrical Impedance' method is accurate, inexpensive, reliable, simple, safe and non-invasive technique for use in lung function laboratories [28, 29].

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