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CORRELATION BETWEEN BODY SIZE PARAMETERS AND LUNG FUNCTION AFTER BRIEF EXERCISE: ASSESSMENT USING MODIFIED BALKE PROTOCOL

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Abstract

We aimed to determine the correlation between height, weight, and BMI on lung function by using modified Balke protocol. The height, weight and BMI of 61 preclinical medical students of RCMP (30 males, 31 female) were measured. The students completed modified protocol by walking on treadmill for 9 minutes. The differences in lung function (FVC, $FEV_1$and FEV_1%) were compared between the pre- and post-exercise state. Participating students were non-smoker and non-alcoholic. A significant correlation was observed between height and the pre- and post-exercise FVC (pre: r=0.650, post: r=0.696) and FEV_1 (pre: r=0.671, post: r=0.671). However, non-significant correlation was observed between height and FEV_1% for both the pre- and post-exercise. As for weight, a significant correlation was observed between weight and the respective FVC (r=0.454) and FEV_1(r=0.458) pre-exercise, but non-significant correlation was observed for FEV1% (r=0.066). On the other hand, both FVC and FEV_1showed a significant increase with weight (FVC by +0.095, FEV_1 by +0.066) post-exercise except for FEV_1 which showed no significant correlation with weight (0.183). No significant correlation was observed between BMI and FVC (pre: r= 0.0141, post: r= 0.255) and FEV_1(pre: r= 0.137, post: r=0.247), and FEV_1% (pre: r= -0.013, post: r= 0.070), respectively, in both the pre- and post-exercise. In conclusion, both height and weight have significant effect on lung function after brief exercise.

Keywords: Lung Function Test, Balke Protocol, BMI.

1. Introduction

BMI imbalance is known to be a major risk of whole range of respiratory disorders. Various studies showed that obesity has various effects on respiratory system by producing obstructive sleep apnoea, obesity hypoventilation syndrome and abdominal compartment syndrome [1]. Under nutrition coexist with obesity thus demonstrating double burden of the disease which occur in most Indo-Asian countries [2].

To investigate the effect of obesity on respiratory system, most researches used values of pulmonary function test (PFT). The spirometry tests measured are the forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), peak expiratory flow rate (PEFR) and forced mid-expiratory flow (FEF 25-75%) and ratio of FEV_1 to FVC was calculated to find the impact of obesity on ventilation. But most of the studies focus on FEV_1, minute ventilator volume and ERV. The major respiratory complications of obesity include a heightened demand for ventilation, elevated work of breathing, respiratory muscle inefficiency and diminished respiratory compliance. The major effects of aerobic exercises are the enhancing of breathing efficiency and to decrease pulmonary resistance and other hand decreases fat percentage. The effect of physical activity was shown in increment of FVC and decrease of resting heart rate. There was a significant difference in the FVC, FEV_1 and the FEF25-75 values between the underweight, normal weight and the overweight subjects. BMI as well as the body fat percentage had a significant negative correlation with FVC and FEV_1 in the overweight group. A significant positive correlation was observed between BMI, body fat percentage and FVC and FEV_1[2]. We intended to investigate the association between lung function test and body size after brief exercise by using Balke Protocol Test. In this study, 60 students consists of 30 male and 31 female is used as sample size. The sample size chosen is due to previous study conducted on effect of acute exercise of pulmonary lung function test of first year MBBS student which also select 30 male and 31 female [3].

2. Methods

2.1 Participants

Sample size was selected by purposely and conveniently which include 61 preclinical medical students (30 male, 31 female).In this research, the first criteria included is students should come from preclinical department and they have agreed to participate in the investigation in order to determine their lung function Next, student must be in healthy condition and have declared that no action will be taken if any emergencies happens during their participation. In this study, we are excluding smokers and alcoholic drinker. The consent form has been prepared and will be distributed among the respondents before the study is conducted .The respondents are invited to join the research study and given enough time to read the information carefully. A written request of permission is required and the potential respondents are advised to give the correct and sufficient information in order to have an accurate result. Qualification and details are also stated which insist the respondents to declare their health status and personal information honestly. If the respondent is unhealthy, they are advisable to not taking part in this research study. Explanation of the purpose, methods and duration of the study is informed briefly to ensure a complete understanding. Respondents can voluntarily withdraw or refuse to take part before or during the study is performed. The respondents are also assured to be clearly acknowledged that they are fully responsible for their participation and the researchers will not be claim for any incidents. Data will be kept private and considered as confidential.

2.2 Anthropometry

The standing height of the subjects was measured with the same measuring tape, without footwear; to the nearest centimetre. Weight was measured, which was the nearest to 0.1 kg, with the subjects in the standing position, before lunch, with light clothes and without footwear, by using a standardized weighing scale [4]. Body mass index [BMI] was calculated by using Quetlet's index [body weight in kg/height in m^2]. Depending on their BMI values, the subjects were classified into three groups.

2.3 Lung Function

The spirometry test is used to measure the lung function of the patiently performing Forced Expiratory Vital Capacity. The respondents were instructed to inhale maximally and exhale into the spirometer with maximum expiratory effort as rapidly and completely as possible. Instructions on breathing procedure were instructed to the respondents. The printed test of lung function was obtained with the results that include the FEV/FVC percentage.

2.4 Balke Protocol

The Balke Protocol is a brief exercise test run using a treadmill established in the 1970s by Bruno Balke. Respondents were asked to run for 9 minutes instead of 9 to 15 minutes in order to keeping the time taken as minimum as possible to make sure that the exercise is only brief and not excessive exercise [5]. For men, the treadmill speed is set as constant at 3.3 mph while the gradient starts at 0%. After 1 minute, the gradient will be increased by 2%. The next minutes, the gradient will be increased by only 1%. For women, the treadmill speed is set as constant at 3.0 mph while the gradient starts at 0%. After 3 minutes, the gradient will be increased by 2.5%. The next 3 minutes, the gradient will be increased again by 2.5%.

2.5 Statistical analysis: The data were analyzed by using the SPSS version 10 [Statistical Package for Social Sciences] statistical software and ANOVA correlations ANOVA was applied for the three groups of BMI in the entire study. FVC, FEV_1 and FEV1% were correlated with BMI, Height, and Weight. The significance level was set at p values which were < 0.05 and it was considered as significant.

3. Results

3.1 participants' characteristic and lung condition

Based on table 1, the gender of the participants were almost equal by 30:31 of male and female. The height group was divided into 4 groups; in which group 1 represents the shortest range while group 4 represents the tallest range. Based on the table, the majority of the participants were categorized under group 2 and the least was in group 4. On the other hand, the weight group was divided into 7 groups, where the lightest was under group 1 and the heaviest was in group 1. Most of the participants were found to be in group 2 and 3. Body mass index (BMI) classified into 4 groups which included underweight, normal, overweight and obese (Table 1).

Table-1: Participants' characteristics and lung condition.

	Frequency	Percent	Cumulative percent
Gender			
Male	30	49.2	49.2
Female	31	50.8	50.8
Height group (cm)			
Group 1(147-157)	17	27.9	27.9
Group 2 (157.1-167.1)	26	42.6	70.5
Group 3 (167.2-177.2)	17	27.9	98.4
Group 4 (177.3-187.3)	1	1.6	100.0
Weight group (kg)			
Group 1 (39-49)	13	21.3	21.3
Group 2 (49.1-59.1)	18	29.5	50.8
Group 3 (59.2-69.2)	18	29.5	80.3
Group 4 (69.3-79.3)	8	13.1	93.4
Group 5 (79.4-89.4)	1	1.6	95.1
Group 6 (89.5-99.5)	2	3.3	98.4
Group 7 (99.6-106.6)	1	1.6	100.0
BMI (kg/m^2)			
Underweight (< 18.5)	6	9.8	9.8
Normal (18.5 - 24.9)	40	65.6	75.4
Overweight (25 - 29.9)	11	18.0	93.4
Obese (>30)	4	6.6	100.0
Lung condition			
Normal	20	32.8	32.8
Restricted	41	67.2	100.0

The results showed that a large amount of participants had a normal BMI and 4 participants were obese. Lastly for the lung condition, only 20 participants were normal and the rest were restricted (Table 1).

Table-2: Linear regression between lung function with height, weight and BMI.

	Unstandardized Coefficients		***Standardized Coefficients***	**t**	**Sig.**	**R^2(%)**
	B	**Std. error**	**Beta (β)**			
Height						
Pre exercise						
FVC	0.683	0.104	0.650	6.568	0.000	42.2
FEV	0.678	0.098	0.671	6.954	0.000	45.1
FEV_1	1.350	0.835	0.206	1.616	0.111	5.3
Post exercise						
FVC	0.739	0.099	0.696	7.447	0.000	48.5
FEV	0.655	0.100	0.649	6.559	0.000	42.2
FEV_1	-0.432	1.063	-0.053	-0.406	0.686	0.3
Weight						
Pre exercise						
FVC	0.284	0.073	0.454	3.911	0.000	20.6
FEV	0.276	0.070	0.458	3.962	0.000	26.9
FEV_1	0.256	0.508	0.066	0.504	0.616	0.4
Post exercise						
FVC	0.348	0.069	0.549	5.051	0.000	30.2
FEV	0.315	0.067	0.524	4.724	0.000	27.4
FEV_1	0.163	0.635	0.033	0.256	0.799	0.1
BMI						
Pre exercise						
FVC	0.164	0.152	0.141	1.074	0.287	2.0
FEV	0.299	0.150	0.255	1.994	0.051	1.9
FEV_1	0.154	0.147	0.137	1.044	0.301	0.0
Post exercise						
FVC	0.273	0.142	0.247	1.921	0.060	6.5
FEV	-0.094	0.947	-0.013	-0.099	0.921	6.1
FEV_1	0.638	1.211	0.070	0.526	0.601	0.5

Table-3: Pearson correlation between lung function with height, weight and BMI.

	Pearson correlation (r)	**Significant**
Height		
Pre exercise		
FVC	0.650	0.000
FEV	0.671	0.000
FEV_1	0.206	0.111
Post exercise		
FVC	0.696	0.000
FEV	0.649	0.000
FEV_1	0.053	0.686

Weight		
Pre exercise		
FVC	0.454	0.000
FEV	0.458	0.000
FEV_1	0.066	0.616
Post exercise		
FVC	0.549	0.000
FEV	0.524	0.000
FEV_1	0.033	0.799
BMI		
Pre exercise		
FVC	0.141	0.287
FEV	0.255	0.051
FEV_1	0.137	0.301
Post exercise		
FVC	0.247	0.060
FEV	0.013	0.921
FEV_1	0.070	0.601

3.2 Pearson Correlation between lung function with height, weight and BMI

The height group was significantly correlated with both FVC (pre: r=0.650, post: r=0.696) and FEV_1 (pre: r=0.671, post: r=0.649) during pre and post exercise and have a strong relationship between these variables (Table 2). Whereas there was no significant correlation for FEV_1% during pre and post exercise with low and very low relationship respectively (Table 2). Other than that, based on table 2 weight group was significantly correlated with both FVC and FEV_1 ($p<0.05$) but have no significant correlation with FEV_1% ($p>0.05$) during pre and post exercise. Weight group has medium relationship with both pre exercise FVC (r=0.454) and FEV_1 (r=0.458) compared to post exercise FVC (r=0.549) and FVE_1 (r=0.524) which has strong relationship (Table 2). Table 2 showed that, there was no significant correlation between weight group with pre and post exercise FEV1% and a very low relationship between the variables. At the same time, the results obtained for BMI group explained that there was no significant correlation between BMI group with pre and post exercise FVC, FEV_1 and FEV_1% ($p>0.05$). The relationships between these variables were low and very low during pre and post exercise (Table 2).

3.3 Linear Regression between lung function with height, weight and BMI

Table 3 showed that height group has a significant correlation with pre exercise FVC ($p<0.05$, β=.650), pre exercise FEV_1 ($p<0.05$, β=.671), post exercise FVC ($p<0.01$, β=.696) and post exercise FEV_1 ($p<0.05$, β=.49). The R^2 indicated that height group affects pre and post exercise FVC as well as pre and post exercise FEV1 by 42.2%, 48.5%, 45.0% and

42.2% respectively (Table 3). Besides, the result obtained for weight group showed that it has a significant correlation with pre exercise FVC ($p<0.01$, $\beta=0.454$), pre exercise FEV_1 ($p<0.01$, $\beta=0.458$), post exercise FVC ($p<0.01$, $\beta=0.549$) and post exercise FEV_1 ($p<0.01$, $\beta=0.524$). Based on table 3, the R^2 value specified that weight group affects pre and post exercise FVC along with pre and post FEV_1 by 20.6%, 30.2%, 21.0% and 27.4% correspondingly. Whereas for both height and weight group, they has no significant correlation with pre and post FEV_1% variable. In addition, BMI also has no significant correlation with all variables neither during pre nor post exercise (Table 3).

4. Discussion

4.1 Heights association with FVC, FEV_1, FEV_1% pre and post exercise

There is a strong correlation between height and pre exercise FVC (r=.650), post exercise FVC (r=.696) and both are significant which means increase of heights would increase their Force Vital Capacity (FVC) before and after exercise. The correlation between height and FVC has been supported in many other studies. For example, a study published in Respiratory Physiology found a strong correlation (R2= .8 or higher depending on the age group) between height and FVC [6].

A strong correlation between Height and pre exercise Forced Expiratory Volume in the first second (FEV_1) was observed (r=.671), also for post exercise (r=.649), both were significant. This is in line with Yohana et al. (1992) showing that there is an increase of correlation between FEV1 and increasing heights [7]. But, there is very low correlation between Height and FEV_1% both before and after exercise which represents one's lung function .There are also insignificant. Contrast, Ostrowski et al. (2006) saying that there is no doubt height are the most important predictors of lung function and Height linearly correlates with lung size [8].From this study, it is true that height correlate with lung size but not the lung function.

4.2 Weight association with FVC, FEV_1, FEV_1% pre and post exercise

Based on Table 13.0 it can be concluded that during pre-exercise, both FVC and FEV_1 have significant correlation and medium relation with weight but FEV_1% has no significant correlation and also has very low relation with weight. On the other hand, during post-exercise, both FVC and FEV_1 have a significant correlation and have increase on its strong relation with weight (FVC by +0.095, FEV_1 by +0.066) but FEV_1% still has no significant correlation and also has slightly increase in its very low relation to weight (0.183).

Our findings are incline with a study conducted by Kappagoda et al. (1979), which proves that the relationship between body weight and oxygen demand were statistically significant. When body mass increases, body will tend to have a greater demand for oxygen in order to suffice the need of metabolic processes and energy expenditure [9]. Thus it is true that FVC and FEV_1 value will increases indicate the bigger volume of expired air.

Lung function or FEV_1% which has no significant correlation towards weight strongly indicates that oxygen and energy is needed based on demand. People with a big body mass might tend to have a bigger proportion of fat than muscle. During aerobic exercise, people need to breathe more often thus oxygen demand is focusing mainly for the respiratory muscle to produce more energy [10]. A body which has less muscle and more fat has lower value of FEV_1% because less oxygen is demanded than people with more muscle mass.

On the other hand, body with a greater proportion of fat demand a lesser amount of oxygen because as mentioned before, muscle will determine the demand for oxygen consumption more than fat in order to produce energy thus body can work more on any activity.

4.3 BMI association with FVC, FEV_1, FEV_1% pre and post exercise

This study analyses BMI with FVC, FEV_1 and FEV_1%. BMI and lung function showed a low relationship, which is insignificant for both pre-exercise and post-exercise result ($p > 0.05$). The pre-exercise FVC with BMI is negatively and insignificantly correlated ($r = 0.0141$) which is similar to the correlation of pre-exercise FEV_1 with BMI that is negatively and insignificantly correlated ($r = 0.137$). However for the pre-exercise FEV_1 % with BMI, it is observed that there is a very negative and insignificant correlation ($r = -0.013$).

In post-exercise FVC, there is a negative insignificant correlation with BMI ($r = 0.255$). In post-exercise FEV_1, there is a negative insignificant correlation with BMI ($r = 0.247$). In post-exercise FEV_1%, there is a very negative insignificant correlation with BMI ($r = 0.070$). Thus, it is disagreeing with study done by Umesh Pralhadrao et al. (2012) [2], which stated that there was a significant difference in FVC and FEV_1 values for the BMI. This is perhaps due to our small sample size population compared to the study. The study also includes that BMI contributes independently to pulmonary function tests with a differences in correlation pattern between males and females.

This association is might due to the fact that BMI illustrates body mass, including skeletal muscle and fat distribution. The accumulation of fat which is known as abdominal obesity includes visceral fat and subcutaneous fat. A study conducted by Umesh Pralhadrao Lad et al. (2012), showed that the association of BMI, body fat percentage and lung function might due to the differences in adiposity pattern of males and females in different BMI .The body fat distribution has an effect on pulmonary function as males have a central obesity, while females have peripheral obesity. The visceral fat deposition is higher in central obesity (in males) where the visceral fat undergoes more favourable adverse metabolism than subcutaneous fat. Excessive accumulation of visceral fat indicated a strong correlation for deteriorated metabolic health and unfavorable cardiorespiratory fitness level. The fat might encroach into the chest wall, diaphragm or even might impede the descent of diaphragm during forced inspiration. Relatively, central obesity may lead to reduction in FVC and FEV_1 by decrease in expiratory reserve volume [11].

Even though BMI is the measurement of weight-height, excess weight-for-height (overweight) might not necessarily be an indication of excess body fat. Relationship between BMI and body fat in gender-specific differences explained that greater lean mass associated with muscular male body build and bone mass. Excess weight-for-height attributable to lean and bone tissue rather than body fat, thus account for prevalence of overweight men according to BMI. It is also observed age- related changes in body composition were consistent with effect of growth hormone prevalence with age.

4.4 Gender association with FVC, FEV_1, FEV_1% pre and post exercise

Gender shows strong correlation with pre exercise FVC ($r=.677$) and it is significant ($p<.05$). There is also a very strong correlation with pre exercise FEV_1 ($r=.713$) and this is also significant ($p<.05$). For pre exercise FEV_1%, the correlation with gender is low but it is significant. Next, for post exercise, FVC and gender shows very strong correlation ($r=.728$) and it is significant ($p<.05$).FEV_1 and gender shows strong correlation ($r=.699$) and it is also significant. Lastly, FEV_1% and gender have no significant relationship between height group and post exercise FEV_1% and the relationship between variables is very low ($r=.053$).

4.5 Limits

The limitation of the present study was in its design. This was a cross- sectional study which was carried out in a small group in a single institution. A longitudinal multi-centric study in a larger group is needed to obtain more accurate findings.

We also measure lung function using a TRANSLAB Electronic Spirometer Model: Chestgraph(H1-101) .The most accurate way is for a person to sit in a body plethysmograph, a sealed, transparent box that resembles a telephone booth, while breathing in and out against into a mouthpiece. Changes in pressure inside the box allow determination of the lung volume. Lung volume can also be measured when a person breathes nitrogen or helium gas through a tube for a specified period of time. The concentration of the gas in a chamber attached to the tube is measured, allowing estimation of the lung volume. Our study results need to be confirmed in a larger group in future studies using a Body Box.

5.0 Conclusion

In conclusion, this study confirms our hypothesis that different body sizes do affect lung function after brief exercise by using Balke protocol significantly in terms of FVC and FEV_1 but were rejected in term of FEV_1% as the result showed insignificant in FEV_1%. There are a lot of factors which could determine the result such as proportion of body muscle and fat, and gender.

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