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Original Research Article

Physiological Standard Curves of Predicted Pulmonary Function Parameters Impacted by Body Surface Area

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Abstract

The objective of the present study was undertaking to estimate the physiological standard curves of predicted PFT parameters (VC, FVC, FEV1, FEV1/FVC, FEF25-75, and PEF) impacted by body surface area in Student College. The study was conducted on 160 healthy non-smoking healthy college students who the aged group 18-25 yrs. Measured the height and weight to calculate the BSA by Mosteller formula and measured PFTs by spirometry.

The statistical analysis that used to get the best physiological standard curves of impact BSA on studied pulmonary parameters showed the effectiveness of BSA by linear- shape regression model on FEF25-75 estimated the highly significant($P<0.01$) highly significant negative correlation coefficients, and on VC that observed significant ($P<0.05$) with significant negative correlation, while on FEV1/FVC that showed non-significant($P>0.05$) with non- significant correlation coefficient. The compound–shape regression model recorded strong highly significant($P<0.01$) with positive and negative highly significant correlation coefficient on the FVC and FEV1 respectively, while by the inverse–shape regression model recorded highly significant ($P<0.01$) with highly significant negative correlation coefficients on PEF.

Firstly we got the best physiological standard curves of predicted PFT parameters impacted by BSA after used linear and non-linear regression various models and various simple linear regression models and their estimates were selected from common bioassay fields. Secondly increases of BSA has impact on PFT values that lead to trouble of airflow rate due to resistance to flowing air in and out of the lung or gaseous exchanges of body demand or chest muscles can't expand enough.

Key Words: Body surface area, physiological standard curves, height, weight, pulmonary function tests.

الخلاصة

تهدف هذه الدراسة الى تقدير المنحنى القياسي الفسيولوجي لقيم وظائف الرئة المتأثرة بالمساحة السطحية للجسم عند طلبة الكلية الاصحاء غير المدخنيين في بغداد.اجريت هذه الدراسة المقطعية على 160 طالبا بمعدل عمر 18–25 سنة وتم تسجيل الجنس والعمر والوزن والطول, واحتساب المساحة السطحية للجسم (BSA)بموجب معادلة موستلر (Mosteller) وكذلك سجلت قيم وظائف الرئة.

أظهر التحليل الاحصائي بطريقة(الانحدار الخطي البسيط)(Linear) ان المساحة السطحية للجسم لها تأثير احصائي ملموسا بدرجة عالية على (FEF25–75) بقيمة ($P<0.01$) وتأثير احصائيملموس بدرجة($P<0.05$)علىVC بينما لم يظهر هذاالتأثيرعلىFEV1/FVC, بدرجة ($P>0.05$)وكذلك سجل افضل منحنى قياسي فسيولوجي للقيم المذكورة أنفا". بينما أظهرت طريقة فحص المركب (Compound) تسجيل تأثير عالي ملموس وبدرجة($P<0.01$)للمساحة السطحية للجسم على FEV1 و FVC وتسجيل افضل منحنى قياسي فسيولوجي. أم الفحص بطريقة (Inverse)سجل افضل منحنى قياسي فسيولوجي لتأثير المساحة السطحية للجسم علىPEFوبتأثير احصائي عالي ملموس وبدرجة $P<0.01$)

أولا: الحصول على أفضل منحنيات فسيولوجية قياسية لقيم وظائف الرئة المسجلة بالدراسة والمتأثرة بزيادة المساحة السطحية للجسم بعد استخدام التحليل الاحصائي الخطي والغير خطي البسيط من خلال استخدامنا للعديد من الطرق المختلفة للفحص. ثانيا: زيادة المساحة السطحية للجسم اثرت بشكل واضح على قيم الرئة والتي ادت الى حدوث مشاكل اما في جريان الهواء من والى الرئة او في تبادل الغازات التي يحتاجها الجسم او نتيجة مشاكل في توسع عضلات الصدر.

Introduction

The total surface area of the human body is known Body Surface Area (BSA), it's used in many measurements in medicine, including the calculation of drug dosages and the amount of fluids to be administered intravenously. Drug doses, fluid therapy, caloric supplies and physiological values such as cardiac output, glomerular filtration rate and a variety of pulmonary function tests are all frequently articulated in terms of a BSA [1,2]. A number of different formulas have been developed over the years to calculate the body surface area and they give slightly different results. The most commonly used formula now is that of Mosteller, it's a scientific formula to estimate BSA from both height and weight. BSA is probably the most used utensil for indexing physiological and biological functions [3]. Many physicians carryon using BSA calculation as an index for physiological parameters such as cardiac output, glomerular filtration rate. The body size (body surface area) is one of the direct factors affect cardiac output , so the cardiac output increases approximately in proportion to the surface area of the body ,and the cardiac output is frequently stated in terms of the cardiac index (is the cardiac output per square meter of body surface area), [1,4] there are relationship between basal metabolic rate,body surface area and respiration this relation indicating or meaning that metabolic reaction of oxygen with carbohydrate and other organic molecules or the exchange of gas between the cells of an organism and external environment [5,6]. Many physiology text-books include a graph of average normal metabolic and basal metabolic rate as a function of weight[1] ,while the body surface area is a function of both height and weight and therefore is a good outward expression of nutritional standard of the individual [7]. Clinically BSA is a better indicator of metabolic mass than body weight because it is less affected by abnormal adipose mass for that the BSA is directly related to Basal Metabolic Rate [BMR] or Resting Metabolic Rate [RMR][8].

The physiological principles underlying pulmonary function in health and disease were understood in surprising detail during past three hundred years[1]. In order to determine lungs capability of holding air ,amount of air moving in and out and how well lungs take in oxygen and remove carbon dioxide from blood , the pulmonary function tests (PFT) must be done, [9] it have not only widened the knowledge about the functional capability of the lungs in normal healthy persons but also have made it possible to assess the functional abnormalities in persons with restrictive and obstructive airway disorders both qualitatively and quantitatively. [7] PFT for lungs can be comparable to the ECG for heart [10]. The application of PFT in diagnosis and management of respiratory diseases is not yet a routine in country like India [11] and in our country too, while Spirometry being the most commonly performed lung function test [9] and the lung has large surface area, high vascularity and thin alveolar epithelium and it is in contact with environmental pollutants lead to illness occur that impair the oxygen saturation of blood which ultimately deranges the function of all the body system, [12] in persons who are exposure to those pollutants, the PFTs are used as a screen tests[13]. Many previous studies explained the pulmonary function tests vary in healthy individuals and are greatly influenced by individual body weight , body height, age, individuals sex, race, nutrition, differences in body building, physical activity, smoking, socioeconomic status, BMI, pollution and environmental factors,[14][15] but few studies focusing on the effectiveness of BSA and its correlation on pulmonary function tests as a separately study.

Physiological, psychological and anatomical factors of individuals contribute to this alteration and it is important to consider biological variations while assessing lung functions. Gender, body size, and age are some factors responsible for variations in lung volumes and capacities among individuals [9].

We did not found studies focused separately on the importance of the BSA and its impact on lung function tests of healthy college students with an average aged of 18-25 years old, especially in the Middle East. Based on our knowledge through research we have not found previous studies to record the physiological standard curves of predicted pulmonary function test.

Hence the present study was undertaken to study the physiological standard curves of predicted pulmonary function parameters (VC, FVC, FEV1, FEV1/FVC, FEF25-75, and PEF) impacted by body surface area in healthy student college in Baghdad.

Materials and Methods

160 university students (87 male and 73 female) belonging to age group of 18 to 25 years from middle class socioeconomic background were recruited for the study on the basis of simple random sampling from post–graduate section of Health and Medical Technical College – Baghdad of Middle Technical University during a period of December 2015 to April 2016. Smoker students and users of tobacco in water pipe were excluded from this study and the students had no history of any cardiopulmonary diseases and were not under any physical conditioning program and or medication.

After approval of institutional ethical committee from volunteer's students and get the permission to conduct the study was obtained from the college administrator. The procedure of the study to obtain the various parameters from studied students was explained and demonstrated to them. For each volunteer three satisfactory efforts were recorded according to the norms given by American Thoracic Society (ATS)[16].

All anthropometric measurements and pulmonary function tests were conducted in one sitting on the same day and wearing light clothing with barefoot.

The anthropometric measurements were recorded from all studied student's included gender, age of each subject was obtained to nearest year from the date of birth in addition to calculated the body height was measured without shoes to nearest 0.1cm in standing upright position and both the heels placed together. Body weight was measured with wearing light clothing with barefoot to nearest 0.5 kg. Body Surface area was calculated from height and weight using Mosteller formula "simplified calculation of body-surface area in metric terms" the body surface area = the square root of product of the weight in kg times the height in cm divided by 3600 [17].

Portable SPIROLAB III computerized spirometer device used for record the values of lung function parameters as per the ATS/ERS [American Thoracic Society/European respiratory Society] guidelines. It had the tests procedure was carried out in standing posture. These tests were recorded in the fore noon to avert the diurnal variations[18]. Firstly the maneuvers were demonstrated, each studied students repeated every maneuver for 3 times and the largest values for each were selected.[19] Forced vital capacity (FVC), Forced Expiratory Volume during 1st second of expiration (FEV1), and ratio of FEV1 to FVC (FEV1/FVC), Peak Expiratory Flow (PEF), Forced Expiratory Flow in 25-75% (FEF25-75) and Vital Capacity (VC)were recordedaccording to ATS/ERS guidelines [16].The studied students had some practice attempts before the readings were taken to be familiar with the measuring spirometer. The participants were encouraged to keep blowing out so that maximal exhalation can be achieved. A spotless, one-use, one-way mouthpiece was attached to the spirometer for each volunteer.

The aim of this present cross sectional study was to elucidate the physiological standard curves of predicted pulmonary function parameters (VC, FVC, FEV1, FEV1/FVC, FEF25-75, and PEF) impacted by body surface area in healthy student college in Baghdad.

Statistical Methods

The following statistical data analysis approaches were used in order to analyze and assess the results of the study under application of the statistical package (SPSS) ver. (18.0):

1. Fitted of the long term trend of simple linear and non- linear regression models.
2. Linear and Non-Linear Regression Models such as (Inverse, Quadratic,

Cubic, Power, Compound, S-Shape, Logistic, Growth and Exponential) as well as simple Linear regression Model with their estimates such that (Slope, Constant, Correlation coefficient, and analysis of regression variance).

For the abbreviations of the comparison significant (C.S.), used the followings:
NS: Non significant at P>0.05 S: Significant at P<0.05 HS : Highly significant at P<0.01

Results

Table (1) of cross sectional our study shows regression models tested in two tailed alternative statistical hypothesis for two factors, body surface area (Independent), on the different parameters, such that (VC, FVC, FEV1, FEV1/FVC , PEF, and FEF 25-75) (Dependents), and as follows:

1. With respect to subject (VC) parameter, linear-shape regression model estimated that with increasing one unit of surface area, occurred decreasing on unit of (VC) parameter, and estimated by (-1.35429), and that recorded significant of effectiveness at P<0.05, as well as strong and highly significant correlation coefficient at P<0.01 are recorded between studied factors, and accounted (0.2021), as well as others source of variations are not in model, i.e. "Constant term in regression equation" shows that non assignable effects that not included in the regression equation, couldn't be neglected, since estimated highly significant at P<0.01.
2. Regarding to subject (FVC) parameter, compound shape regression model estimated that with increasing one unit of surface area, occurred increasing on unit of (FVC) parameter, and estimated by (2.056996), and that recorded highly significant of effectiveness at P<0.01, as well as strong and highly significant correlation coefficient at P<0.01 are recorded between studied factors and accounted (0.3365), as well as others source of variations are not in model, i.e. "Constant term in regression equation" shows that non assignable effects that not included in the regression equation, couldn't be neglected, since estimated highly significant at P<0.01.
3. Concerning subject (FEV1) parameter, compound-shape regression model estimated that with increasing one unit of surface area, occurred decreasing on unit of (FEV1) parameter, and estimated by (0.611703), and that recorded highly significant of effectiveness at P<0.01, as well as strong and highly significant correlation coefficient at P<0.01 are recorded between studied factors, and accounted (0230), as well as others source of variations are not in model, i.e. "Constant term in regression equation" shows that non assignable effects that not included in the regression equation, couldn't be neglected, since estimated highly significant at P<0.01.
4. Concerning subject (FEV1/FVC) parameter, linear-shape regression model estimated that with increasing one unit of surface area, occurred weak decreasing on unit of (FEV1/FVC) parameter, and estimated by (2.72799), and that recorded non- significant of effectiveness at P>0.05, as well as weak and no significant correlation ship coefficient at P>0.05 are recorded between studied factors, and accounted (0.03112), as well as others source of variations are not in model, i.e. "Constant term in regression equation" shows that non assignable effects that not included in the regression equation, couldn't be neglected, since estimated highly significant at P<0.01.
5. In relation to subject (PEF) parameter, inverse - shape regression model estimated that with increasing one unit of surface area, occurred decreasing on unit of (PEF) parameter, and estimated by (8.563379), and that recorded highly significant of effectiveness at P<0.01, as well as strong and highly significant correlation coefficient at P<0.01 are recorded between studied factors, and accounted (0.22876), as well as others source of variations are not in model, i.e. "Constant term in regression equation" shows that non assignable effects that not included in the regression equation, could be neglected, since estimated no significant at P>0.05.
6. Concerning to subject (FEF 25-75) parameter, linear - shape regression model estimated that with increasing one unit of surface area, occurred decreasing on unit of (FEF 25-75) parameter, and estimated by (1.84015), and that recorded highly significant of effectiveness at P<0.01, as well as strong and highly significant correlation coefficient at

P<0.01 are recorded between studied factors, and accounted (0.25096), as well as others source of variations are not in model, i.e. "Constant term in regression equation" shows that non assignable effects that not included in the regression equation, couldn't be neglected, since estimated highly significant at P<0.01.

Table 1: Effectiveness of Body Surface Area on PFT parameters

Parameter	Linear-Shape Model				
VC	Correlation Coefficient	20210.	Tested in two tailed alternative Statistical hypothesis(STRONG RESULTS)		
	F =	6.7258	Sign. F =	0.0104 (S)	
	Variables in the Equation				
	Variable	B	SE.B	Beta	t-test	Sig. of (t)
	S.A.	-1.35429	0.522203	-0.20207	-2.593	0.010
	(Constant)	5.384539	0.917956	-	5.866	0.000
Parameter	Compound-Shape Model					
FVC	Correlation Coefficient	0.3365	Tested in two tailed alternative Statistical hypothesis(STRONG RESULTS)			
	F =	20.1731	Sign. F =	0.0000 (HS)		
	Variables in the Equation					
	Variable	B	SE.B	Beta	t-test	Sig. of (t)
	S.A.	2.056996	0.330317	1.400017	6.227	0.0000
	(Constant)	1.093322	0.308623	-	3.543	0.0005
Parameter	Compound -Shape Model					
FEV1	Correlation Coefficient	230210.	Tested in two tailed alternative Statistical hypothesis (STRONG RESULTS)			
	F =	8.8418	Sign. F =	0.0034 (HS)		
	Variables in the Equation					
	Variable	B	SE.B	Beta	t-test	Sig. of (t)
	S.A.	0.611703	0.101111	0.794369	6.050	0.0000
	(Constant)	7.783861	2.261713	-	3.442	0.0007
Parameter	Linear-Shape Model					
FEV1/FVC	Correlation Coefficient	031120.	Tested in two tailed alternative Statistical hypothesis (WEAK RESULTS)			
	F =	0.1532	Sign. F =	0.696 (NS)		
	Variables in the Equation					
	Variable	B	SE.B	Beta	t-test	Sig. of (t)
	S.A.	-2.72799	6.969705	-0.03112	-0.391	0.696
	(Constant)	87.38675	12.25172	-	7.133	0.000
Parameter	Linear-Shape Model					
PEF	Correlation Coefficient	228760.	Tested in two tailed alternative Statistical hypothesis(STRONG RESULTS)			
	F =	8.7248	Sign. F =	0.0036 (HS)		
	Variables in the Equation					
	Variable	B	SE.B	Beta	t-test	Sig. of (t)
	S.A.	8.563379	2.899136	0.228758	2.954	0.0036
	(Constant)	0.095865	1.687491	-	0.057	0.9548
Parameter	INVERSE-Shape Model					
FEF 25-75	Correlation Coefficient	250960.	Tested in two tailed alternative Statistical hypothesis(STRONG RESULTS)			
	F =	10.6199	Sign. F =	0.0014 (HS)		
	Variables in the Equation					
	Variable	B	SE.B	Beta	t-test	Sig. of (t)
	S.A.	-1.84015	0.564665	-0.25096	-3.259	0.0014
	(Constant)	6.926331	0.992599	-	6.978	0.0000

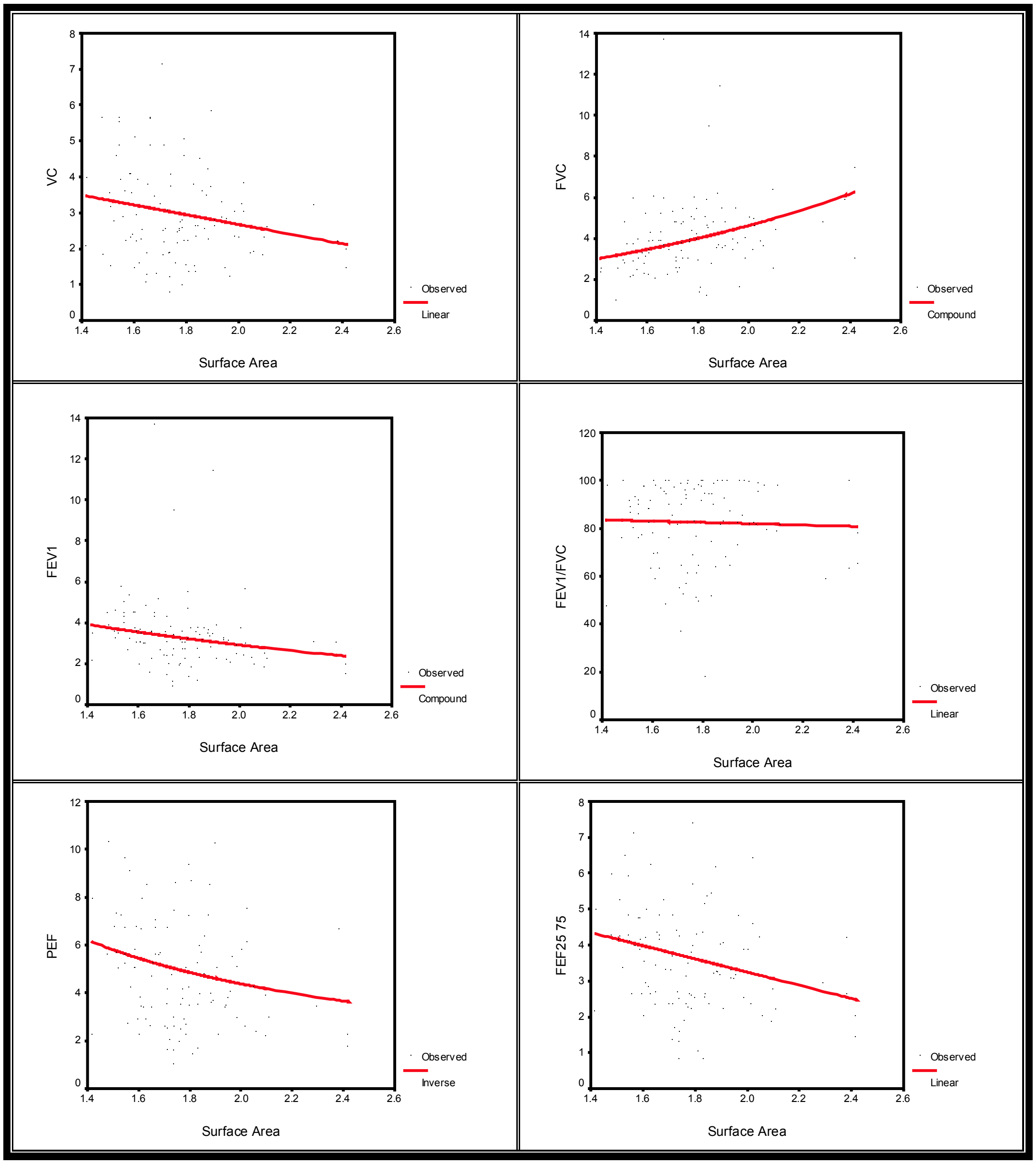

Figure 1: Long term trends regressive of scatter diagrams of surface area factor on the studied parameters

Discussion

Linear and Non-Linear regression models such as (Inverse, Quadratic, Cubic power, Compound, S-shape, Logistic, Growth, and Exponential) was used in this study, as well as simple linear regression model with estimates such that (Slop, Constant, Correlation coefficient, and Analysis of regression variance) to get the best physiological standard curves of predicted PFT parameters impacted by BSA in students college aged.

Our statistical analysis results of linear and non-linear regression models exhibited that the independent body surface area factor has a strong significant correlation coefficient on different dependent factors of pulmonary function parameters (VC, FVC,FEV1,FEF25-75, and PEF) except the FEV1/FVC parameter that recorded a weak and non- significant correlation with BSA.

Vital capacity (VC) was defined as a change in volume of lung after maximum inspiration followed by maximum expiration, it is the sum of tidal volume (TV), inspiratory reserve volume (IRV) and expiratory reserve volume (ERV)[9]. The VC primarily reflects the ability of lung and chest to expand [20] The statistical analysis of linear –shape model verified strong and significant negative correlation coefficient, with refer to the long term trends regressive of scatter diagram(1) of BSA on VC we showed that linear regression estimated thatincreasing BSA decreasing VC.In the previous studies, no indication to the kind of correlation between VC and BSA, was found.

We suggested the negative correlation coefficient may be either due to decrease in all three above components of VC or one of them, or may be the thoracic expands not well proper because the VC is a simple measure of pulmonary capacity that usually in restrictive disorder occurs when the thorax can't expand enough and this creates problems with air flow,[9] so the reduction of VC indicates restrictive impairment[21].The functional residual volume (FRC) and expiratory residual volume affected by changes in body weight from over weight to all the degree of obesity as a result of the altered thoracic wall mechanics on obesity, there are a relatively repaid decrease in FRC and ERV in over weight and mild obesity states,[22] there was a significant negative correlation between VC and weight as well as negative correlation between body fat percentage and EFV, but positive correlation with height [23].

Resting metabolic rate (RMR) measurement by indirect calorimetry requires qualification of O_2 consumption and CO_2 production while a subject is resting and because RMR is proportional to the BSA based on the physiological basis for body size influence on metabolic rate [6].Results of his study, suggest in this point the Residual volume increases to supply the O2 requirements to the body during force expiration when the increase body surface area.Ojo*et al* showed that negative correlation of VC with adiposity [23], our studied students are not active students due to not rigours college and in addition to the hostels near the college area that allow students to accumulation of adiposity in upper or lower body regions that may explain negative correlation of vital capacity with adiposity.

Force vital capacity (FVC) is the maximum volume of air which can be exhaled or inspired maneuver and its readings as the accurate measure of lung capacity [24]. The statistical analysis of compound–shape regression model verified strong highly significant positive correlation ship coefficient between BSA and FVC.Refer to scatter diagram (Fig1) of BSA and FVC that showed increased BSA increased FVC and the shape of diaphragm appeared concave in the middle that indicate to decline in the rate of air flow over the middle half of the FVC between 25 to 75%.

The FVC represents by dimension of lung, respiratory muscle compliance and power,[25] and FVC correlated inversely with body fat% in both gender that suggested displacement of air by fat within the thorax and abdomen[26]. The positive correlation observed in the our study are generally in agreement with previous studies described by other investigators[15, 25, 27, 28, 29, 30]. We can suggest that the positive correlation between FVC and BSA be explained by the greater body surface area greater oxygen demand for body metabolism and greater elimination of carbon dioxide from body.

FEV1 is the volume of exhaled air during the first second of a force vital capacity maneuver is a useful measure of how quickly the lungs can be emptied[31].The statistical analysis of compound–shape regression model verified strong highly significant negative correlation coefficient between BSA and FEV1. Refer to scatter diagram (Fig1) of BSA and FEV1 showed that increase BSA decrease FEV1.Our recorded values were not agreement with previous studies [11,15, 25, 27,28,29,30]. Most widely used ofFEV1 value is to measure the mechanical properties of the airways size(medium and large).It reduces in both obstructive and restrictive disease, lower value of FEV1 indicated to restrictive pulmonary defect due to mechanical limitation of thoracic expansion because a weakness in muscles of the respiration, [32,33] or as accumulation of excess adipose tissues that interferes with the movement of thoracic wall and diaphragm, this may reflect intrinsic changes within the lung [32]. Both FVC and FEV1 is the lung functions most closely related to body composition and fat distribution [34].

FEV1/FVC is the percentage of FVC expelled in the first second of force expiration. The statistical analysis of linear – shape regression model exhibited no significant of BSA impact on FEV1/FVC as well as weak result of non-significant correlation coefficient between them. Refer to the scatter diagram(1) showed slightly decreased in FEV1/FVC when increased BSA but remains within normal rang and from scatter diagram of FVC showed the first 25% increases not affected by FEV1/FVC because weak correlation non-significant affecting by BSA. Our result was agreement with previous study of Meenakshisharma et al 2013 that conducted on children of 7-14 years.[15] During age and body surface area progressives showed increase FVC, FEV1, FEV1/FVC%,[35] we suggested that indirect effect of increases BSA on spirometer volumes and capacities to supply body requirement of O_2 and removed CO_2. The non-significant effectiveness of BSA on FEV1/FVC indicates to normal inspiratory and expiratory muscle strength [26] that explain our present observation of positive correlation of FVC with BSA.

FEF25-75means the rate of airflow over the middle half of the FVC between 25% and 75% of FVC[31]. The statistical analysis of linear – shape regression model verified strong highly significant negative correlation coefficient between them. Refer to scatter diagram (Fig1) of BSA and FEF25-75 showed that increase BSA decrease FEF25-75.From definition of FEF25-75and decline of scatter diagram of FEF25-75 that interpret the slightly decline in the middle of scatter diagram of FVC and give the reasons of concavely middle shape of FVC diagram. We not found in the previous studies any indication to the kind of correlation between BSA and FEF25-75.

Peak Expiratory Flow(PEF)is useful test of ventilator function capacity,[36] it measure how fast a person can exhale using greatest effort thus it is regarded as a basic physiological parameter for diagnosis,[3,37] it’s sensitive indicator to measure the strength of muscles of respiration and dependent upon airway resistance and maximal voluntary muscular effort,which measures the airways caliber.[36] The statistical analysis of inverse–shape regression model verified highly significant impact of BSA on PEF, and the scatter diagram(1) exhibited strong highly significant negative correlation between them. Our result of negative correlation of BSA with PEF not agreement with results of many previous studies that showed positive correlation of coefficient in school children aged [25,36] in addition to not agreement too with previous studies that conducted on wide age range subjects(18-50yrs)[28,38]. We suggested form the above and our observation about negative correlation of PEF with BSA that higher BSA, may be higher airway resistance, the lower PEF. Meenakshi *et al* that observed a positive correlation between PEFR and FEV1 or FVC in children of 7-14 years and they explain PEFR and FEV1 tests are used in interchange, [39] that explain and support our results of negative correlation of both FEV1 and PEF with BSA.

Decline in PEF, FEV1, and FEF25-75 of our study showed in the lightly middle concave shape of FVC scatter diagram while the last 25% of FVC indicated to elevation of all changes that may lead to decline in VC when increases in BSA, we can suggest the causes may be due to decrease in pulmonary expansion, decrease in ERV and increase in FRV that needed by the body for gaseous exchange after force expiratory effort because BSA have direct proportional with BMR[6] for supply oxygen to maintain body metabolism.

Body surface area is a good outward expression of nutritional standard of the individual because it is a function of both height and weight[7]. The BSA when increase it mean increase in height and weight or in body weight only (after stop in increasing of individual height), the effective of weight greater than effective of height due to increase in body mass (fat or muscular mass). [7] Weight may have effect on PFTs including, dysfunction of small airway, expiratory flow limitation,alteration in respiratory mechanics, decline in thoracic wall and pulmonary compliance, decrease pulmonary gas exchange, and lower in control of breathing[40,41]. The study students come from standard of living is less than average they can't put forth a greater muscular effort that lead to decrease PEF reading[42].

Conclusion

1-we got the best physiological standard curves of predicted PFT parameters impacted by BSA after used linear and non-linear regression various models and various simple linear regression models and their estimates were selected from common bioassay fields.

2- increases in body surface area has independent effects on ventilator function through multiple mechanisms (trouble in airflow rate,gaseous exchanges of body demands) in addition to its direct mechanical effect on the chest wall, metabolism and energy requirements

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