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SPIROMETRIC VALUES AMONG YEMENI UNDERGRADUATE STUDENTS IN UNIVERSITY OF SCIENCE AND TECHNOLOGY, YEMEN, SANA'A CITY

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ABSTRACT

Normal values of spirometry for the healthy population are affected by different anthropometric, demographic (Height, weight, sex, and age), ethnic, geographic and climatic factors. This study aimed to measure normal values of spirometry for Yemeni undergraduate students in University of Science and Technology in Sana'a city. By using spirometer, 155 spirometry datasets collected between May, 2016 to Oct.2017 were carried out on healthy and non-smoking individuals; 62 males and 93 females aged between 18-25 years. Multiple regression analysis was used to develop predicted equations for use in Yemeni population. The result of the Forced Vital Capacity (FVC/L) was (3.87±0.63 versus 2.79±0.39, P value<0.001), and that of Forced Expiratory Volume in the first second was (3.68±0.58 versus 2.52±0.38, P value<0.001). Moreover, the ratio of FVC/FEV1 was (94.79±5.27 versus 90.37±10.58, P value=0.001) and that of Maximum Voluntary Ventilation MVV (L/min) was (140.03±28.41 versus 92.63±19.48, P value=0.001) which were significantly higher in males than females. Irrespective of gender, all spirometric parameters increased with the increase of age and had a positive correlation with height and weight. They also had no correlation between parameters and Body mass index. Our measured values of spirometry were significantly lower than Caucasian predicted values. There is a real need for further larger studies to develop predicted equations based on normal spirometric values for Yemeni population, including all ages and both genders living in different climates of the country.

KEYWORDS: Pulmonary Function Tests, Predicted Equations, Spirometry & Yemeni Population

INTRODUCTION

In pulmonary medicine, proper history with physical examination and pulmonary function tests (PFTs) provides an important step in assessing the respiratory status. The measurement of PFTs is very important in the identification and management of respiratory diseases (obstructive or restrictive) as well as measuring the severity of these diseases (Fawibe et al. 2017). Spirometry is the most widely and preferred test used for early detecting and diagnosing of chronic obstructive pulmonary diseases (COPD) which expected to be the third cause leading to death in 2020 (Lubiński et al. 2010), also used for monitoring lung function decline (Chavez et al. 2009). Moreover, spirometry is used to monitor the effectiveness of therapy, to screen individuals at risk of having pulmonary diseases such as smokers or individuals with occupational exposure to toxic substances in occupational surveys and to monitor adverse reactions to drugs with known pulmonary toxicity (Brusasco et al. 2005). Spirometry is also highly informative, accessible, inexpensive and easy to perform (Barreiro et al. 2004, Tan et al. 2011, Chhabra et al. 2014).

Spirometry is the measurement of the air moving in and out of the lung during respiratory breathing (Crapo et al. 2001). It determines how much and how fast air can be inhaled and exhaled (Al-Ashkar et al. 2003). Most of the biological indices in medicine such as plasma concentration of chemical substances or hormones have “normal values” applicable to all individuals in the population (Chhabra et al. 2014), but pulmonary function tests, unlike them, are affected by ethnicity, gender, age, weight, standing height, environmental, genetic, socio-economic and occupational factors (Fawibe et al. 2017). For the interpretation of tests, the result consequently must be compared with expected normal values of the subject with a particular gender, age, ethnic, racial origin and physical characteristics. These are called “predicted” values developed by analysis of data collected from non-smoking and healthy individuals of the same population (Chhabra et al. 2014). Therefore, it is essential to know the normal range-upper and lower limit of normal-ULL and LLN of these measurements for each racial group, taking other variables into consideration (Quanjer et al. 2012)

In the last few decades, many researchers have conducted lung function studies in many countries to detect their own normal reference values of spirometry. They showed wide differences in predicted values according to the difference in ethnicity (Fawibe et al. 2017). Consequently, predicted values for a specific population cannot be applied on another population, for example, the application of Caucasian predicted values on a non-Caucasian population results in a major error of interpretation, and thus affecting the management (Stanojevic et al. 2010). Therefore, it is necessary that a patient’s data are interpreted in the light of normal predicted values for the same ethnicity (Miller et al. 2005).

Many reference values of spirometry are available, but most of them are related to western population, leaving the rest of the world uncovered, despite of the effects of different ethnicity on lung functions. For example, American Thoracic Society (AST) recommended the use of the Third National Health and Nutrition Examination Survey (NHANES III) as a reference for the spirometric function for the African-American and Mexican-American population (Hankinson et al. 1999). The European Community for Steel and Coal produced reference values for the Europe population (Degens et al. 2008). Global Lung Function Initiative (GLI) in 2012 is also applicable globally to another different ethnic group such as Australia, Brazil, France, Italy, Israel and United Kingdom (Quanjer et al. 2012). All of these surveys did not give any significant attention to the Arab world.

Different studies from other countries like Malaysia, Canadian and Northern India respectively have their own reference values (Bandyopadhyay 2011, Tan et al. 2011, Chhabra et al. 2014).

Few Arab countries, including Saudi Arabia (Belacy et al. 2014), Sudan (Bashir et al. 2012), Oman (Al-Rawas et al. 2009), Jordon (Sliman et al. 1981), have produced their own reference values for spirometric functions as predicted equations.

In Yemen, there have not published studies yet regarding the normal spirometric values. Therefore, the present study aimed at measuring spirometric values among healthy Yemeni undergraduate students in the Faculty of Medicine and Health Sciences at University of Science and Technology, Sana’a, in which the spirometric values were carried out from May, 2016 to Oct. 2017.

OBJECTIVES OF THE STUDY

To measure the normal values of spirometry and their relation to anthropometric measurements for Yemeni undergraduate students in the Faculty of Medicine and Health Sciences at University of Science and Technology in Sana’a city.

METHODS

A cross-sectional study was conducted at the Physiology Department, on one hundred fifty five (n=155) Yemeni adult participants; 62 males and 93 females aged between (18-25) years who were selected from the students of the Faculty of Medicine and Health Sciences, University of Science and Technology, Sana'a, Yemen. According to inclusion and exclusion criteria of this study, only Yemeni nationals of either gender, who had never smoked cigarette, had no history of previously diagnosed cardiorespiratory diseases, no history of abdominal, thoracic or eye surgery, and no history of heart attack in the last six months, were without cardiorespiratory symptoms and without any evidence of cardiorespiratory abnormality on physical chest examinations, and were able to perform spirometry satisfactory, were eligible to participate in this study. The height in centimeter (cm) was measured for the participants who stood up with their back to the wall without shoes and their feet are flat on the ground and opposed at medial malleoli. They stood up as tall as possible with the eyes level and looked straight ahead (Miller et al. 2005) by a stadiometer. By a sensitive electronic balance, the weight in Kilograms (kg) was measured for the participants who were barefoot and wore light clothing. The height and weight of each participant were used to calculate Body Mass Index (BMI) by this formula: body mass index = weight (kilograms)/height (meter2). Spirometry was performed using a spirometer (Spiro lab III MIR Italy) which has an auto sensor turbine for body temperature, pressure and water vapor saturated (BTPS) changes. This equipment was calibrated daily with a 3L syringe. Measurement of spirometric parameters was made in an upright sitting position with a nose clip closed to the nostrils. Tight clothing around the neck and chest was loosened to fully allow the chest expansion and prevent alteration of the test result (Miller et al. 2005). Each participant made to be familiar with the machine and technique of the test after the explanation of the test procedure. Tests were performed while the participants were seated comfortably on chairs. The spirometric parameters (FVC, FEV1, FEV1/FVC % and MVV) were recorded and each maneuver had to meet the American Thoracic Society (ATS) acceptability and reproducibility criteria (Miller et al. 2005). If both criteria were not met, the procedure was repeated at least three and up to eight maneuvers at a short period of time in order to avoid fatigue which may lead to littleadded values of additional maneuvers (Miller et al. 2005). The highest values of FVC, FEV1 and their ratios were selected and recorded for each participant.

Data Analysis

Suitable tables were used for the presentation of data. After the data collection of data, they were entered into the computer and analyzed by using the statistical package for social science SPSS (version 23).

The data were expressed as mean ± SD (standard deviation). A two-group comparison was done by using a student-test. Pearson correlation and simple linear models were used to study the correlation between dependent and independent variables. In addition, an intergroup comparison was done by utilizing One-Way Analysis of Variance (ANOVA) when three or more variables were compared. Multiple linear regression was used to identify the predicted equations for participants regarding age, sex, height , and weight.

The results were considered significant if P value < 0.05.

ETHICAL CONSIDERATION

The study was approved by the Ethics Committee of the Faculty of Medicine and Health Sciences at University of Science and Technology, Yemen. There are no unexpected complications through the using of a spirometer, and oral informed consent was taken from the participants after a full explanation of the nature of the study. The participants were free to leave the study at any stage.

RESULTS

The present study was conducted in the Physiology Department lab at University of Science and Technology during the period from May 2016 to Oct. 2017.

This study was conducted on 155 participants made up of 62 (40%) adult males and 93 (60%) adult females who completed the spirometric measurements according to the ATS reproducibility and acceptability criteria included in this analysis. The response rate was 155/216*100=71.8%.

The mean age for males and females, respectively was 21.94±1.93 and 20.82±1.89 year, the mean height was 166.40±4.46 and 154.55±5.84 cm, the mean weight was 63.61±14.95 and 54.40±10.47 kg, and the mean BMI was 22.92±5.05 and 22.80±4.44 kg/m2 (Table 1).

Table 1: Mean and SD of Demographic and Anthropometric Characteristics of Male and Female Participants

Parameter	Males (n=62) Mean±SD	Females (n=93) Mean±SD	Total (n=155) Mean±SD	T test	p-value
Age (year)	21.94±1.93	20.82±1.89	21.26±1.98	3.58	<0.001
Height (cm)	166.40±4.46	154.55±5.84	159.29±7.89	14.30	<0.001
Weight (kg)	63.61±14.95	54.40±10.47	58.08±13.21	4.21	<0.001
BMI (kg/m^2)	22.92±5.05	22.80±4.44	22.85±4.68	0.15	0.833

SD: Stander deviation

As shown in Table 2, the mean (±SD) values of spirometric measurements (FVC, FEV1, FEV1/FVC %, MVV) in male adult participants were significantly higher than spirometric values of adult female participants (P <0.001).

Table 2: Mean and SD Values for (FVC, FEV1, FEV1/FVC, and MVV) of the Participants According to Sex

Parameter	Male (n=62) Mean±SD	Female (n=93) Mean±SD	t-test	P-value
FVC (measured)	3.87±0.63	2.79±0.39	12.05	<0.001
FEV1 (measured)	3.68±0.58	2.52±0.38	13.84	<0.001
FEV1\FVC (measured)	94.79±5.27	90.37±10.58	3.44	0.001
MVV (measured)	140.03±28.41	92.63±19.48	11.46	<0.001

Table 3 shows that the mean values of FVC, FEV1, MVV of the participants with age group > 20 year were significantly higher than those with age group ≤ 20 years, while for FEV1/FVC Ratio, there was no statistically significance with age groups.

Table 3: Spirometric Parameters Values in Yemeni Participants According to Age Groups

Parameter	≤20 (n=57) Mean±SD	>20 (n=98) Mean±SD	t-test	P-value
FVC (measured)	2.96±0.72	3.37±0.70	-3.52	0.001
FEV1 (measured)	2.67±0.69	3.16±0.71	-4.13	<0.001
FEV1\FVC (measured)	90.14±10.21	93.30±8.20	-2.00	0.049
MVV (measured)	100.24±29.56	118.19±33.24	-3.37	0.001

Regarding the relation between the mean (±SD) of FVC, FEV1, FEV1/FVC % and MVV with the height group, it was clear that the spirometric parameter values increased with increasing height (Table 4).

Table 4: Mean and SD of Spirometric Parameters of Study Participants by Height Groups

Variable	FVC measured Mean±SD	FEV measured Mean±SD	FEV1\FVC measured Mean±SD	MVV measured Mean±SD	Test
Height (cm)					ANOVA
141 – 150	2.66±0.33	2.43±0.35	91.85±10.41	91.9±17.35	
151 – 160	2.80±0.36	2.54±0.36	90.31±10.13	95.28±19.15	
161 – 170	3.57±0.64	3.34±0.65	93.33±7.99	125.05±33.49	
>170	4.57±0.55	4.34±0.45	95.17±4.25	159.39±32.33	
p-value	<0.001	<0.001	0.211	<0.001	

Regarding the relation between the mean (±SD) of FVC, FEV1, FEV1/FVC % and MVV with the weight group, it was clear that the spirometric parameter values increase with increasing weight except in weights > 80 kg because there was a drop in values (Table 5).

Table 5: Mean and SD of Spirometric Parameters of Study Participants by Weight Groups

Weight (kg)	FVC measured Mean±SD	FEV measured Mean±SD	FEV1\FVC measured Mean±SD	MVV measured Mean±SD	Test
31 – 40	2.55±0.38	2.44±0.37	96.02±4.51	100.37±7.33	ANOVA
41 – 50	2.79±0.41	2.53±0.39	90.88±10.28	97.27±23.19	
51 – 60	3.26±0.68	2.99±0.70	91.73±10.11	109.33±33.22	
61 – 70	3.51±0.70	3.36±0.71	93.83±6.95	124.89±35.45	
71 – 80	3.81±0.91	3.51±0.88	92.22±7.04	136.25±35.88	
>80	3.6±0.91	3.35±0.93	92.5±7.79	117.26±35.06	
p-value	<0.001	<0.001	0.701	<0.001	

In Table 6 which shows the mean and SD of spirometric parameters in male and female participants by BMI, there was a statistical significance in all spirometric parameters of males except in FEV1/FVC %, and there was not a statistical significance in all parameters of females except in MVV.

Table 6: Mean and SD of Spirometric Parameters of Males and Females by BMI

Variable	BMI	Male		Female		Test
		Mean±SD	p-value	Mean±SD	p-value	
FVC measured	<18.5	3.22±0.45	0.002	2.61±0.37	0.222	ANOVA
	18.5 - 24.9	3.97±0.55		2.78±0.43		
	≥ 25	4.01±0.70		2.87±0.43		
	Total	3.87±0.63		2.79±0.39		
FEV measured	<18.5	3.05±0.30	0.002	2.35±0.35	0.071	
	18.5 - 24.9	3.78±0.52		2.49±0.36		
	≥ 25	3.78±0.64		2.66±0.44		
	Total	3.68±0.58		2.52±0.38		
FEV1\FVC measured	<18.5	95.46±6.15	0.844	89.76±12.65	0.842	
	18.5 - 24.9	94.88±5.60		89.86±10.71		
	≥ 25	94.21±4.10		91.39±9.88		
	Total	94.79±5.27		90.37±10.58		
MVV measured	<18.5	120.94±23.1	0.009	87.55±13.31	0.027	

	18.5 - 24.9	148.58±25.22		89.59±19.08		
	≥ 25	130.99±31.39		101.99±20.86		
	Total	140.03±28.41		92.63±19.48		

On studying the correlation between height, weight and BMI with spirometric parameters, it was clear that FVC, FEV1 and MVV had a significant positive correlation with height and weight, and had no correlation with BMI. On the other hand, FEV1/FVC % had no significant correlation with height, weight and BMI (Table 7).

Table 7: Correlation of FVC, FEV1, FEV1/FVC Ratio and MVV with Height, Weight and BMI in All Participants

Parameter	Height\cm		Weight\kg		BMI (kg/m^2)	
	r	p-value	R	p-value	r	p-value
FVC (measured)	.725**	<0.001	.464**	<0.001	0.144	0.075
FEV (measured)	.709**	<0.001	.461**	<0.001	0.148	0.067
FEV1\FVC (measured)	0.089	0.639	0.044	0.854	-0.007	0.933
MVV (measured)	.586**	<0.001	.332**	<0.001	0.076	0.346

Note: ** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level (2-tailed)

Table 8 shows that the measured values for FVC, FEV1 and MVV in Yemeni participants were significantly lower than the corresponding Caucasian predicted values with a maximum mean difference percentage of FVC (15.5%), while the measured values for FEV1/FVC ratio in Yemeni participants were significantly larger than the predicted values of Caucasian.

Table 8: Comparison of the Measured and the Predicted Values Based on Reference Caucasian Values of Different Spirometry Parameters for Yemeni Adult Students (n=155)

Parameter	Measured value Mean±SD	Predicted value Mean±SD	Mean difference percentage	t- test	*P*-value
FVC (liter)	3.22±0.73	3.81±0.68	15.5%	7.40	<0.001
FEV1 (liter)	2.98±0.74	3.30±0.56	9.7%	4.25	<0.001
FEV1\FVC %	92.14±9.08	83.76±0.86	-10.0%	-11.43	<0.001
MVV (liter)	111.59±33.00	120.49±16.36	7.4%	3.01	0.003

The predicted equations for the spirometric parameters are shown in Tables 9 and 10 as:

$$X = a + (H*b) + (S*c) + (W*d)$$

Where, (X) is the mean predicted spirometric parameter's value, (a) is a constant, and (b, c, d) are regression coefficients for independent variables; (H) height, (S)sex and (W) weight.

These equations were suitable for male and female subjects with age ranged between 18-25 years, with height ranged between 142-183 cm and body weight ranged between 37-123 kg.

Table 9: Predicted Equations for FVC, FEV1, FEV1/FVC% and MVV in the Present Study (Male)

Variable	Equation
FVC measured	= -8.359+ (Height in cm x 0.070) + (Weight\kg x 0.009)
FEV1 measured	= -8.607+ (Height in cm x 0.071) + (Weight\kg x 0.008)
FEV1\FVC measured	Not done because all variables except sex had no a statistical significance to the outcome

Table 9: contd.,	
MVV measured	= 108.204+ (Age x 1.033) + (Weight\kg x 0.144)

Table 10: Predicted Equations for FVC, FEV1, FEV1/FVC% and MVV in the Present Study (Female)

Variable	Equation
FVC measured	= -0.489+ (Height in cm x 0.019) + (Weight\kg x 0.007)
FEV1 measured	= -1.199+ (Height in cm x 0.006) + (Weight\kg x 0.008)
FEV1\FVC measured	Not done because all variables except sex had not a statistical significance to the outcome
MVV measured	= 61.990+ (Age x 0.565) + (Weight\kg x 0.347)

DISCUSSIONS

Pulmonary function tests (PFTs) with the proper history and physical examination collectively are used in respiratory care to identify the pattern of respiratory disorder (obstructive, restrictive) and its severity (Al-Ashkar et al. 2003).

Spirometry is the most important test to measure the ventilatory function of the respiratory system (Fawibe et al. 2017), and is able to identify the obstructive pathology 5-15 years prior to other techniques (Johns et al.).

The current study aimed to measure the spirometric values among healthy undergraduate Yemeni students (62 males and 93 females) in the Faculty of Medicine and Health Sciences at University of Science and Technology, Sana'a, Yemen. Similar to most of the previous studies, regarding the demographic and anthropometric variables, this study concluded that height, age, sex and weight correlate with the variation of pulmonary function values (Belacy et al. 2014, Fawibe et al. 2017).

This study also showed that all the spirometric parameters are affected by the sex of the participants. FVC, FEV1, FEV1/FVC, and MVV were significantly higher in males than females. This is similar to results reported by other studies (Ali et al. 2007, Alghadir et al. 2011, Bashir et al. 2012, Belacy et al. 2014, Desai et al. 2016). This could be explained by the differences in respiratory muscles strength, fat- free mass, size and shape of the thoracic cage. These possible reasons were more in males than females due to the effect of androgen hormones which makes the adult males have the bigger size of the lungs and airways than the adult females (Mengesha et al. 1985, Stocks et al. 1995, Saleem et al. 2012). In our study, the FEV1/FVC ratio was more in males than females, while other studies reported that the FEV1/FVC ratio was more in females than males (Al-Rawas et al. 2009, Chhabra et al. 2014, Fawibe et al. 2017) but the study of (Kang et al. 2013) suggested that the FEV1/FVC% did not correlate with gender.

This study also found that the FVC, FEV1, and MVV significantly increased with increasing age. FEV1/FVC also increased with age but this relation was not significant. Our study does not agree with the study of (Belacy et al. 2014) which was performed on a sample of Saudi adults and concluded that age has no effect on lung functions. Moreover, other studies have shown a negative correlation between age and spirometric parameters (Ferguson et al. 2000, Boskabady et al. 2002, Garcia-Rio et al. 2004, Nku et al. 2006, Ali et al. 2007, Kang et al. 2013, Chhabra et al. 2014, Fawibe et al. 2017). The result of our study may be explained due to the narrow age group of our sample (between 18-25 years), where the lung function increases slightly between the age of 16 up to 25., After that, there is a decline with age (Falaschetti et al. 2004). Therefore, the highest values of spirometric parameters occur in this age group (Bashir et al. 2012). Other studies (Hankinson et al. 1999, Tan et al. 2011) which covered wide age ranges (8-80 years and 20-90 years respectively), suggested that the age was an effective independent factor on lung functions. The study of Al-Rawas et al. (2009) agrees with the present study only in FEV1/FVC% ratio which increased with increasing age.

The present study concluded that the height was the most important variable affecting all the spirometric parameters by a significant positive correlation except the FEV1/FVC ratio which was insignificantly affected. Many studies have similar findings to our results (IP et al. 2000, Falaschetti et al. 2004, Nku et al. 2006, Ali et al. 2007, Al-Rawas et al. 2009, Bashir et al. 2012, Belacy et al. 2014, Chhabra et al. 2014, Desai et al. 2016, Fawibe et al. 2017). Moreover, the study of Brändli et al. (1996) on a sample of a Swiss population and the study of (Facchini et al. 2007) on a sample of a Kazakhstani population suggested that the observed changes in lung function are due to only changes in height. This could be explained by the taller persons who have bigger lung size which leads to more lung volumes and capacities. In some studies, there was an exception for FEV1/FVC% ratio which decreased with increasing height (Al-Rawas et al. 2009, Kang et al. 2013).

Although our study found that the weight has a clear effect on spirometric parameters. This effect was small statistically significant. This conclusion is similar to that of the other studies (Nku et al. 2006, Bashir et al. 2012, Belacy et al. 2014, Chhabra et al. 2014), which suggested that there was a small significantly positive correlation between weight and spirometric parameters. In the study of Desai et al. (2016), it was suggested that the weight effected on the spirometric indices but it was not significant. On the contrary, the study of Pereira et al. (2007) reported that there was a negative correlation between weight and spirometric parameters only for males not for females. The difference between gender could be as a reflection to a different obesity pattern-abdominal pattern in males which more significantly affected the ventilatory lung functions, but in females, a peripheral pattern of obesity did not affect the parameters (Pereira et al. 2007). Furthermore, the study of Garcia-Rio et al. (2004) concluded that the spirometric parameters were not affected by weight because their subjects were with a narrow weight range. In addition, this study showed that the spirometric parameters decreased at a maximum extreme of weight > 80 kg. The same result was found in Bashir et al. (2012). On the contrary, Garcia-Rio et al. (2004) concluded that there was no significant difference in spirometric parameters with both extremes in the study subjects.

The present study found that all spirometric parameters had a weak positive correlation with BMI, and the FEV1/FVC ratio did not have a significant correlation with BMI> This probably was because most of our participants have normal BMI. The average BMI of our healthy participants was 22.85±4.68. Similarly, the study of Garcia-Rio et al. (2004) on elderly European males and females concluded that there was no relationship between BMI and spirometric parameters, which might be as a reflection of a narrow weight range in their elderly subjects. They also said that the absence of relationship was because both FVC and FEV1 depend on body composition more than BMI which is a determinant of adiposity. The study of Ali et al. (2007) also suggested that the BMI did not significantly associate with spirometric parameters, which might be because only subjects with normal BMI ranging from 17-25 kg/m2 were included in their study. The study of Saleem et al. (2012) reported that spirometric parameters were higher in low BMI (<18.5 kg/m2) in both genders.

Ethnicity has been considered as one of the major factors responsible for a wide variation in normal values of ventilatory functions (Hooper et al. 2013). Therefore, necessary reference values must be relevant to the ethnic characteristics of the local population (Fawibe et al. 2017). The differences in lung functions according to ethnicity explained by several factors mostly related to the characteristics of body size and shape (IP et al. 2000).

By comparing our results to those of other studies with different ethnicity, our study found that the means of FVC and FEV1 for male and female participants were nearly equal to the measured values of the study performed on three hundred healthy non-smoking Saudi students of the same age group (18-25 years) (Belacy et al. 2014). The equal values might be due to the similarity of age, weight and height range between the two studies, as well as the similarity of geographic factors such as altitude between the two countries, while MVV measured values in our study were larger. The lower MVV among Saudi adults may reflect their lower physical fitness secondary to a sedentary lifestyle than the Yemeni adults.

While our mean values of the present study were larger than the mean values obtained by the study performed on 2250 healthy Sudanese aged between 7-86 years (Bashir et al. 2012). This may be as a reflection of our population at a higher altitude than Sudanese which makes us more hypoxic and provides us with more ventilation, more lung volumes, and capacities or makes effects of hot climate on Sudanese which decreases ventilation. The effect of climate on lung function was reported by many studies (Brändli et al. 1996, Nku et al. 2006), and the effect of altitude on lung function was reported by Saleem et al. (2012).

But in comparing our measured values of FVC and FEV1 parameters with those of Gordian, Australian, Canadian and Nigerian studies (Sliman et al. 1981, Gore et al. 1995, Tan et al. 2011, Fawibe et al. 2017), they were smaller. This observation could be as a result of a difference in many factors between us and these countries such as genetic constitution which is related to height. Their population is taller than ours. Therefore, their participants had bigger lung sizes, more lung volumes and capacities, more altitude and air pollution, nutritional and socio-economic state, and physical activity (Saleem et al. 2012). On the contrary, the measured value of FEV1/FVC% ratio in our study was larger than theirs. This is because the FEV1/FVC% ratio depends on the ratio between the maximum effort in the first second (needed for FEV1) and the sustained effort needed for the whole FVC. the later may be better in these populations than in the Yemeni population (Belacy et al. 2014).

In the present study, we found that our measured values of spirometric parameters (FVC, FEV1, and MVV) were generally lower than the predicted values based on pre-programmed Caucasian reference values, while the measured value of a ratio between FEV1/FVC % was significantly larger than the predicted values of Caucasian. Our results agree with the results of previous studies (Al-Rawas et al. 2009, Alghadir et al. 2011, Bashir et al. 2012, Musafiri et al. 2013, Belacy et al. 2014), where the non-Caucasians races have decreased the dynamic lung volume to Caucasians (Alghadir et al. 2011). This might be explained by the fact that the Caucasian is taller (height) than the non-Caucasian, which could be attributed to the genetic factors that control the body growth (Hankinson et al. 1999). On the contrary, the higher value of FEV1/FVC % in Yemeni adults are compared to those of the Caucasians, Canadians and Australians. This observation was not only in Yemeni adults or Arab studies, but was also in agreement with ATS statement (Miller et al. 1992), which concluded that the non-Caucasian races show similar or higher FEV1/FVC% to the Caucasian. This is because the FEV1/FVC% depends on the ratio between the maximum effort in the first second (needed for FEV1) and the sustained effort is needed for the whole FVC. The later may be better in the Caucasian than in other ethnic groups (Belacy et al. 2014). The larger lung volume in the Caucasian contributed to increased number of alveoli and larger chest cavities (Donnelly et al. 1991).

In our equation, height was the most important predictor of spirometric parameters and some anthropometric variables such as age and weight, which improved the accuracy of the estimation, while BMI did not significantly contribute to the prediction. The predicted equation for FEV1/FVC ratio was not done because all variables except sex were not statistically significant with the outcome.

Because the other factors, which affect the lung function such as the genetic factors and environmental factors (air pollution, altitude, nutritional and socioeconomic) are not easily quantified. They could not be taken into consideration as predictor factors. This observation agrees with many previous studies in their equations (Facchini et al. 2007, Pereira et al. 2007, Chhabra et al. 2014).

CONCLUSIONS

This study has assessed the normal spirometric values and predicted equations for both sexes; Yemeni adult students. The mean FVC, FEV1, MVV, FEV1/FVC % were higher in males than females. Height and age had a positive correlation with spirometric parameters and weight positively affected the spirometry but with small correlation, while BMI was not significantly associated with spirometric parameters.

In addition, this study concluded that the interpretation of spirometric lung function tests of Yemeni adults, based on the Caucasian prediction set as a default in many western made spirometers, is generally not valid, because the spirometric, parameters in Yemeni participants are lower than the Caucasian reference values. Consequently, there is a real need for further larger studies to cover the large sample size representing all Yemeni populations of all age groups to derive reference values and predicted equations which could be beneficial in clinical practice.

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