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Brief communication (Original)

Ventilatory function among healthy young Saudi adults: a comparison with Caucasian reference values

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Background: Ethnic differences in lung function are recognized. However, most of the modern lung function equipments are pre-programmed with Caucasian reference values.
Objective: Measure spirometric values among healthy Saudi male and female adults and compare with the Caucasian reference values in a standard spirometer.
Methods: Thirty healthy Saudi young adults (15 males and 15 females; mean age 25 years) participated in this study. Forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC (%), and maximal voluntary ventilation (MVV) were recorded using a portable digital spirometer.
Results: Mean values of FVC, FEV1, FEV1/FVC (%) and MVV for the Saudi subjects were significantly lower than the Caucasians predicted values.
Conclusion: Interpretation of lung function tests of Saudi subjects based on the Caucasian prediction equations is generally not valid, as the parameters of lung function tests in Saudi subjects are lower than the Caucasian reference values. The present results underline an urgent need for larger studies to develop prediction equations based on normative spirometric values for Saudi population involving subjects of all ages and both genders living in different climates of the country.

Keywords: Caucasian, pulmonary function test, Saudi healthy adults, ventilatory function

Many studies have established the role of spirometery in understanding normal and pathological function of the respiratory system [1]. The data on lung function tests using spirometry help clinicians in screening, diagnosis, monitoring, and prognosis assessment of respiratory function and dysfunction in different conditions and diseases affecting the airflow in lungs during respiration [2]. In addition, spirometry can be a helpful tool for evaluation of breathing reserve and exercise tolerance to determine physical fitness of healthy subjects [3]. Spirometry is not only a relatively inexpensive method, but it has been shown to be a reliable and reproducible technique to study lung function [4].

The measurement of air volumes during inhalation and exhalation as a function of time provides the physiological basis of spirometry [1]. Among many parameters using spirometry, most commonly used parameters are vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and maximal voluntary ventilation (MVV). The VC is the maximum volume of air that can be expelled from the lungs after a maximum inspiration. FVC is the volume of air that can forcibly be blown out after full inspiration, FEV1 is the maximum volume of air that can be forcibly blow out in the first second during the FVC manoeuvre. FEF25-75% is the average speed of air coming out of the lungs during the middle portion of the expiration. Finally, MVV is the maximum volume of air that can be inhaled and exhaled in one minute [5].

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It is well recognized that different factors, such as subject age, gender, height, and race or ethnicity, influence the lung function [6]. Previous studies have shown that non-Caucasians ethnicities, such as African [7], Chinese [8], Indians [9], and Saudis [10], have lower lung function values for their body size than Caucasians. Such differences are reported to be present in all age groups, including adults, adolescents, children, and infants. In addition, it has been suggested that environmental factors, including nutrition, physical activity, air pollution and socioeconomic status, can affect lung function [8]. In fact, the spirometric values in a group of high altitude residents in a Himalayan region of Nepal were found to be larger than Caucasians [11]. There were altitude-related changes in spirometric values in a group of mountaineers when spirometry was performed at the sea level and at different altitudes [12]. Thus, it is important to have reference values from healthy populations for comparison. Ideally, the reference values should be obtained from the ethnic population in question. However, most of the modern lung function equipments are pre-programmed with Caucasian reference values. Therefore, in some countries, the predicted values for non-Caucasians are sometimes decreased by 12% [13].

Previous studies on lung function tests involving Saudi subjects [10, 14] were conducted more than two decades ago. Thus, there is a need to re-examine the studies and update the reference data after every few years by considering new developments in lung function equipment, measurement procedures and protocols, and any change in respiratory function in different generations of same population due to environmental influences and continuing changes in contemporary life style [13].

In this study, we measured spirometric values among healthy Saudi male and female adults and compared with pre-programmed Caucasian reference values in standard spirometery. We hypothesize that spirometric values among healthy Saudi male and female adults would be smaller than the Caucasian reference values.

Materials and methods

Subjects

Thirty healthy Saudi adults, 15 males (aged 19-29 years, mean age: 26) and 15 females (aged 18-31 years, mean age: 24) participated in this study. The subjects were selected from physical therapy students at College of Applied Medical Sciences, King Saud University, or their healthy friends or relatives, according to inclusion and exclusion criteria of this study. Only healthy Saudi nationals of either gender and native residents of Riyadh were eligible to participate in this study. Tobacco users (smoking, chewing) and persons with musculoskeletal deformities involving vertebral column and thoracic cage, chronic or acute respiratory infections, cardiac problems and obesity (body mass index (BMI) >25 kg/m^2) were not eligible to participate in this study.

The study complied with the ethical standards of King Saud University for human research. All subjects gave their informed consent. Prior to the selection of subjects, power analysis was performed based on the SD of 17.5 for MVV found in a previous study [15]. A sample size of 30 subjects resulted in greater than 90% power to detect 20 litres mean difference between Saudi and Caucasian populations for maximal voluntary ventilation.

General characteristics of all subjects are shown in **Table 1**.

Measurements and procedure

This study was carried out at the Cardiopulmonary Laboratory, College of Applied Medical Sciences, King Saud University. For each subject, portable height and weight scales were used to note height (cm), while standing without shoes and weight (kg) for calculation of BMI. Age in years was also noted for each subject. Pulmonary function tests were performed using a portable spirometer Pony Fx (COSMED, Rome, Italy),

Table 1. Mean and standard deviation of age, weight, height, and BMI for adult. Saudi males (n = 15) and females (n = 15).

	Age (years)	Weight (kg)	Height (cm)	Body mass index (BMI) (kg/m^2)
Male	26.4 ± 7.3	76.2 ± 11.4	175.2 ± 5.7	24.2 ± 3.2
Female	23.7 ± 3.6	60 ± 7.5	157.9 ± 7.2	24.5 ± 2.2

by a trained technician of lung function. The tests were conducted following instructions of the spirometer and in accordance with the Guidelines for Sandardization of Spirometry [16]. All tests were carried out between 9 am to 12 noon to minimize diurnal variation [15]. The spirometer was calibrated daily, and tests were conducted at a room temperature ranging between 20-25°C. Each subject was informed in detail about all test procedures and was asked to practice the test maneuver before performing the test.

Tests were performed while subjects were seated comfortably in a chair. The FVC, FEV1, FVC1/FVC ratio, and MVV were recorded and before every maneuver, appropriate required instructions were given to each subject. In an attempt to obtain reproducible tests with technical acceptability according to the Guidelines for Standardization of Spirometry, each maneuver was performed for three to five times by every subject. The largest values for each parameter from acceptable tests were selected [16].

Statistical analysis

Mean and standard deviation (SD) were used for descriptive statistics. The differences between observed Saudi values and corresponding Caucasian predicted values for FVC, FEV1, FEV1/FVC (%) and MVV, respectively, were compared by one-tail paired t-test with a significance level of <0.05. The software package SPSS version 10 was used for all statistical analyses.

Results

Male subjects

Table 2 shows the mean and SD of observed values for FVC, FEV1, FEV1/FVC (%), and MVV in Saudi men and the corresponding Caucasian predicted values. The observed values for FVC, FEV1, and MVV in Saudi men were significantly lower than the corresponding Caucasian predicted values. Furthermore, the observed value for FEV1/FVC (%) in Saudi men was significantly larger than the corresponding Caucasian predicted values.

Female subjects

Table 3 shows the mean and SD of observed values for FVC, FEV1, FEV1/FVC (%), and MVV in Saudi women and the corresponding Caucasian predicted values. The observed values for FVC, FEV1, FEV1/FVC (%), and MVV in Saudi women were lower than the corresponding Caucasian predicted values. However, the significant differences were found for FVC, FEV1, and MVV.

Table 2. Mean, standard deviation (SD) and statistical comparison of the observed and the predicted values based on the reference Caucasians values of different pulmonary function parameters for adult Saudi males (n = 15).

	Observed value (Mean ± SD)	Predicted value (Mean ± SD)	Mean difference	P-value
FVC	4.2 ± 0.4	5.1 ± 0.3	17.6%	<0.001
FEV1	3.7 ± 0.4	4.3 ± 0.3	14.0%	<0.001
FEV1/FVC (%)	87.8 ± 7.6	81.9 ± 1.5	-5.9%	0.004
MVV	116.4 ± 26.9	148.9 ± 7.4	21.8.0%	<0.001

FVC= Forced vital capacity, FEV1= forced expiratory volume in one second, MVV= maximal voluntary ventilation.

Table 3. Mean, SD and statistical comparison of the observed and the predicted values based on the reference Caucasians values of different pulmonary function parameters for adult Saudi females (n = 15).

	Observed value (Mean ± SD)	Predicted value (Mean ± SD)	Mean difference	P-value
FVC	2.9 ± 0.4	3.5 ± 0.3	17.1 %	<0.001
FEV1	2.4 ± 0.5	3.0 ± 0.3	20.0 %	<0.001
FEV1/FVC (%)	82.3 ± 8.7	84.1 ± 0.8	2.1 %	0.222
MVV	51.2 ± 14.4	111.2 ± 5.7	54.0 %	<0.001

FVC= Forced vital capacity, FEV1= forced expiratory volume in one second, MVV= maximal voluntary ventilation.

Discussion

The present study was aimed to compare spirometric values among healthy Saudi male and female adults with predicted values based on pre-programmed Caucasian reference values in standard spirometery. The present results show that the observed values for studied parameters of lung function tests (FVC, FEV1, FEV1/FVC (%) and MVV) in Saudi adult males and females were generally lower than the predicted values based on pre-programmed Caucasian reference values. Especially, for males, the observed values for FVC, FEV1, and MVV were significantly lower and FEV1/FVC (%) was significantly larger than the corresponding Caucasian predicted values. On the other hand, for females, the observed values for all parameters were lower than the corresponding Caucasian predicted values. However, the difference for FEV1/FVC (%) was not statistically significant.

Our results are in line with many previous studies on lung function tests in non-Caucasian populations from different parts of the world [7-10], where the non-Caucasians have decreased lung volumes and expiratory flow rates compared with Caucasians. Our data show that among Saudi male and female subjects, the respective values for FVC and FEV1 are lower than the predicted Caucasians values with same BMI, but these values are still within the lower normal limit of the predicted values. On the other hand, in males, the FEV1/FVC (%) value is higher, and in the females, it is lower than the predicted value. However, the FEV1/FVC (%) values for both male and female subjects are exceeding the upper limit of the normal range (70%-80%). The FEV1/FVC (%) values below and above this range are indicative of restricted lung disease [5]. Based on the reference Caucasians values, our FEV1/FVC (%) values of healthy male and female subjects can be mistaken for some asymptomatic restricted lung disease if the ethnicity factor is not taken into account. These observations reiterate that the importance of reference normative lung function data should be drawn from the same population under study. The lower MVV values among Saudi subjects might be a reflection of their lower physical fitness levels, secondary to sedentary life style, than their Caucasians counterparts. This is more prominent in female subjects who observe restricted outdoor and physical activities in accordance with Saudi social customs.

The usefulness of spirometery in screening, diagnosis, and prognosis assessment of respiratory function in different conditions and diseases causing restrictive airflow during respiration, such as asthma and chronic obstructive pulmonary disease (COPD), is well established [2]. Like many other laboratory measurements, the effective interpretation of spirometery results is mainly dependent on the reference values from healthy subjects. However, different factors ranging from subject age, gender, height, race or, ethnicity, and environmental factors such as nutrition, physical activity, air pollution, socioeconomic status, and altitude from sea level can influence the lung function. Thus, ideally the reference normative values should also be obtained from the ethnic population in question with similar environmental and other factors.

In Saudi Arabia, it is estimated that more than two millions Saudis are affected by asthma [17], and over 1.2 million are affected by COPD [18]. In our search of Pubmed, only four studies were available on spirometric values involving Saudi subjects [10, 14, 19, 20]. There is a scarcity of data on normative lung function tests for Saudi population. Most data are more than two decades old, and most were confined to subjects living in Coastal areas. On the other hand, it has been shown that dry and humid climates can affect lung function [21]. Since the studies involving Saudi subjects were conducted, there have been new developments in lung function equipments and new recommendations for measurement procedures and protocols [15]. Although our data generally corroborate the results of previous Saudi studies, a direct comparison of the present and previous results is not made in this study because of differences in the characteristics (age, and gender of subjects) and the equipment used for lung function tests.

In absence of valid reference data for Saudi population, for clinical practice in Saudi Arabia, either the invalid reference values based on old studies or prediction equations from Caucasians are being used. In either case, it affects the valid interpretation of the lung function tests. The present results underline the need for larger studies to gather normative spirometric values for Saudi population involving subjects of all ages and both genders living in different climatic conditions of this vast country ranging from inland desert dry environment to coastal humid environment.

In conclusion, the interpretation of lung function tests of Saudi subjects, based on the Caucasian prediction set as default in many western made spirometers, is generally not valid, because the parameters of lung function tests in Saudi subjects are lower than the Caucasian reference values. The present results underline an urgent need for larger studies to develop prediction equations based on normative spirometric values for Saudi population.

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