

# Sex-Based Differences in Lung Functions of Saudi Adults

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**Abstract.** [Background] Sex-based differences in lung function are known. [Purpose] To investigate sex-based differences in ventilatory function among Saudi adults, and to relate it to their level of physical activity. [Subjects and Methods] Seventy healthy Saudi adult subjects (35 males and 35 females) participated in this study. Measurements of forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC%, and maximal voluntary ventilation (MVV) were made. In addition, physical activity scores (MET-minutes/week) were measured using the International Physical Activity Questionnaire (IPAQ). [Results] The studied parameters were significantly higher for males than for females. The female values were significantly lower even after the male values were adjusted to compensate for gender-based anatomical and physiological differences in lung capacity. The MET-minutes/week was significantly higher for males than for females, but it was not significantly correlated with the pulmonary function parameters of either gender. [Conclusions] There are sex-based differences in lung function parameters of Saudi adults, with higher values for males. This difference in lung function tests between the genders is greater than the known anatomical and physiological differences in the respiratory systems of males and females. Saudi males are more physically active than females but no significant correlation between pulmonary function parameters and physical activity score was found for either gender.

**Key words:** Spirometry, Pulmonary function, Saudi adults

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## INTRODUCTION

A growing body of knowledge based on studies conducted over the last two decades suggests sex-based differences exist in normal physiological functions and the pathophysiology of diseases of different organ systems<sup>1)</sup>. These differences have been reported for the cardiovascular<sup>2)</sup>, musculoskeletal<sup>3)</sup> and immune systems<sup>4)</sup>, and in the cellular mechanisms of sex steroid hormone actions on non-reproductive tissues in males and females<sup>5)</sup>.

It is well known that lung function capacity is influenced by the sex of the subject as well as other factors including age, height and ethnicity<sup>6)</sup>. Women tend to have 20–25% lower lung capacity than men<sup>7)</sup>, and this difference is attributed to the smaller lung size of women. The relatively narrow airways in the lungs of females result in lower lung diffusion capacity than males. The difference in lung diffusion capacity remains lower in females even when these values are normalised for height differences between males and females<sup>8)</sup>.

Many different lung function parameters can be studied by spirometry. The most commonly studied parameters include: (i) vital capacity (VC), the maximum volume of air

that can be expelled from the lungs after maximum inspiration; (ii) forced vital capacity (FVC), the volume of air that can forcibly be blown out after full inspiration; (iii) forced expiratory volume in one second (FEV1), the maximum volume of air that can be forcibly blow out in the first second during the FVC manoeuvre; and (iv) maximal voluntary ventilation (MVV), the maximum volume of air that can be inhaled and exhaled in one minute<sup>9)</sup>.

It is common knowledge that higher levels of physical activity result in higher levels of general fitness, and it is also thought that physical activity can improve cardio-respiratory fitness<sup>10)</sup>. A positive relationship between physical activity and cardio-respiratory function of healthy men and women between 25–55 years of age has been shown by cross-sectional (at a given point in time) and longitudinal (time series or over time) data. Longitudinal data have revealed that changes in respiratory function related to physical activity are sex based, and differences are only found among men<sup>11)</sup>. A study to assess the relationship between physical activity and the rate of decline in lung function among boys and girls between the ages of 7–17 with cystic fibrosis showed that the least active girls had the most rapid rate of decline in their lung

**Table 1.** Mean and standard deviation of age, height, weight and BMI of adult Saudi males and females.

	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m <sup>2</sup> )
Males (n=35)	28.7 ± 6.8	175.5 ± 8.1	75.8 ± 10.2	24.8 ± 2.8
Females (n=35)	23.7 ± 3.6	165.4 ± 10.4	66 ± 12.5	24.2 ± 2.6

function<sup>12</sup>). Taken together, these data not only suggest a relationship between pulmonary function and sex of the subject, but also a relationship between the levels of physical activity and pulmonary function.

A recent study of the physical activity profile of Saudi adults living in Riyadh showed that the prevalence of physical inactivity among Saudi adults is relatively high<sup>13</sup>. The study revealed that over 43% of the subjects did not participate in any type of moderate-intensity physical activity lasting for at least 10 minutes per week. In addition, more than 72% of the subjects did not practice any type of vigorous exercise or activity lasting for at least 10 minutes per week. Furthermore, Saudi females generally engaged more in moderate physical activity than males, and males engaged more in vigorous activity than females<sup>13</sup>.

Previous studies of lung function involving Saudi subjects have shown that the parameters of lung function tests in Saudi subjects are lower than the Caucasian reference values<sup>14,15</sup>. Since there is a relationship between the levels of physical activity and pulmonary function<sup>11,12</sup>, it would be of interest to learn about sex-based differences in pulmonary function in Saudi adults who are known to have relatively inactive life styles<sup>13</sup>. Thus, the aim of this study was to investigate sex-based differences in ventilatory function among Saudi adults, and to relate the pulmonary parameters to their levels of physical activity.

## SUBJECTS AND METHODS

Seventy healthy adults, 35 males (aged 21–41 years; mean age 29, SD 6.8) and 35 females (aged 19–42 years; mean age 24, SD 3.6) participated in this study. The general characteristics of the subjects are shown in Table 1.

Only healthy native Saudi nationals of either gender were eligible to participate in this study. Tobacco users (smoking, chewing) and persons with chronic or acute respiratory infections, cardiac problems, musculoskeletal deformities involving vertebral column and thoracic cage, and obesity (BMI > 25 kg/m<sup>2</sup>) were excluded from the study. The purpose of the study was explained to all the subjects, who gave their informed consent to participation in the study. The study fully complied with the ethical standards for human research of King Saud University.

For each subject, height in centimetres during standing without shoes, weight in kilograms and age in years were measured or noted. The body mass index (BMI) was also calculated. Pulmonary function tests were conducted using a portable spirometer, Pony Fx (COSMED, Italy), by a trained lung function technician. The spirometer was calibrated daily. The test procedures were performed in accordance with the guidelines for standardization of spirometry<sup>16</sup> and the operating instructions given in the user's manual of the spirometer. The test recordings were

made at 20–25° C room temperature, and between 9 am to 12 noon to minimize diurnal variation<sup>17</sup>.

Tests were performed while subjects were seated comfortably in a chair. Subjects received detailed instructions about the test procedures, and they practiced the manoeuvre before the test was recorded. The FVC, FEV1, FEV1/FVC% and MVV were recorded. In order to obtain reproducible tests with technical acceptability according to the guidelines for standardization of spirometry, each subject repeated each manoeuvre for three to five times. The largest value for each parameter from acceptable tests was selected for use in the analysis<sup>16</sup>. An automated feature of the spirometer used in this study helped to identify tests with recorded parameters outside acceptable criteria. On-screen evaluation of the spirometry for smoothness of curve, proper start, duration and end of test was also used to ensure that the tests gave results within acceptable criteria.

For each subject, physical activity scores were measured using the short form of the International Physical Activity Questionnaire (IPAQ), available online at [www.ipaq.ki.se](http://www.ipaq.ki.se). Physical activity scores were computed using face to face interviews by a trained data collector. The interviews were conducted on the same day as the ventilatory function tests. The IPAQ assesses physical activity performance during leisure time, household chores, gardening, and work hours and related transportation. The items in the IPAQ form used in this study were structured to provide separate scores on walking, moderate-intensity and vigorous-intensity activities. IPAQ defines moderate physical activities as those that produce a moderate elevation of respiratory rate, heart rate and sweating of at least 10 minutes duration. Vigorous physical activities are defined as those producing vigorous increases in respiratory rate, heart rate and sweating of at least 10 minutes duration<sup>18</sup>.

The physical activity score (MET-minutes/week) was computed by multiplying the number of minutes per week spent on each type of activity with the specific MET score for that activity. Where, one MET is an equivalent of a person's resting metabolic rate, or 3.5 ml/kg/min of oxygen consumption. Thus, physical activity score (MET-minutes/week) = total activity (walking + moderate activity + vigorous activity) × METs of each activity<sup>19</sup>.

The mean and standard deviation (SD) are used for descriptive statistics. The differences between values of FVC, FEV1, FEV1/FVC% and MVV, for male and female subjects, respectively, were compared by the one-tail unpaired t-test. In addition, to exclude the effect of the normal physiological differences of 20–25% (mean 22.5%) lower lung capacity of females<sup>7</sup>, the 77.5% values of the lung function tests for male subjects were also compared with the values for female subjects using the one-tail unpaired t-test. The differences between the mean values of

**Table 2.** Mean, standard deviation, differences and statistical comparison of different pulmonary function parameters between Saudi males (n = 35) and females (n = 35).

	Males	Females	Difference (mean)	Difference (%)
FVC (litres)	4.1 ± 0.7	2.7 ± 0.5	1.4	34
FEV1 (litres/s)	3.6 ± 0.6	2.1 ± 0.6	1.5	42
FEV1/FVC%	89%	78%	11	12
MVV (litres/min)	110 ± 27	48.5 ± 15.6	61	54

**Table 3.** Mean, standard deviation, differences and statistical comparison of different pulmonary function parameters between Saudi males (adjusted values) (n = 35) and females (n = 35). For explanation see text.

	Males	Females (77.5% of recorded values)	Difference (mean)	Difference (%)
FVC (litres)	3.2 ± 0.5	2.7 ± 0.5	0.5	16
FEV1 (litres/s)	2.8 ± 0.5	2.1 ± 0.6	0.7	25
FEV1/FVC%	87.5%	78.2%	9.3	11
MVV (litres/min)	81.9 ± 25.3	48.5 ± 15.6	33.4	41

the physical activity scores of the male and female subjects were compared by the one-tail unpaired t-test. The Pearson Product Moment Correlation Coefficient test was used to determine the relationship between pulmonary parameters and physical activity score. The null hypothesis was rejected at the 0.05 level of significance. The software package SPSS version 10.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

## RESULTS

Table 2 shows the mean and SD of FVC, FEV1, FEV1/FVC% and MVV values for the male and female subjects. All values were significantly higher for males (34%, 42% and 12%, and 54% respectively), than the corresponding values for females ( $p < 0.001$ ).

Table 3 shows a comparison of 77.5% of the mean and SD of FVC, FEV1, FEV1/FVC% and MVV values for males with values for female subjects. The values for male subjects were significantly higher (16%, 25% and 11%, and 41% respectively), than the corresponding values for the females ( $p < 0.001$ ).

The physical activity score (MET-minutes/week) was significantly higher for the male subjects, (range 120 to 8232; median 1386) than for the female subjects (range 158 to 2506; median 975), ( $p = 0.03$ ).

Correlation between pulmonary parameters and physical activity score.

The data showed no significant correlation between the pulmonary parameters and physical activity scores for either the male or female subjects ( $p > 0.05$ ).

## DISCUSSION

The purpose of the present study was to investigate sex-based differences in lung function among Saudi adults, and to determine whether the pulmonary function parameters are related to levels of physical activity. The data revealed sex-based differences in lung function tests. The FVC,

FEV1, FEV1/FVC% and MVV values were significantly higher for males than the corresponding values for females. It was found that the FVC, FEV1, FEV1/FVC% and MVV values for females were significantly lower than the male values, even when the values for females were compared with the male values (77.5% of the mean values) adjusted for the normal physiological difference of 20–25% (mean 22.5%) lower lung capacity in females than males<sup>7)</sup>. The physical activity score (MET-minutes/week) of males was significantly higher than that of the female subjects. No significant correlation between pulmonary function parameters and physical activity score was found in either gender.

The finding of greater lung function test values for males than females corroborates previous data on spirometry<sup>6)</sup>, and normal sex-based anatomical differences in the respiratory system<sup>7)</sup>. It has been reported that the diameter of the respiratory airways is smaller in women than in height-matched men<sup>20)</sup>. It is also reported that women have smaller lung volumes and diffusion surfaces<sup>21)</sup>. Thus, the lower lung function test values of female subjects in this study can be attributed to gender related differences. However, it is interesting to note that the values for females were significantly lower than those of the males even when they were compared with male values (77.5% of the mean values) adjusted for the normal physiological difference of 20–25% (mean 22.5%) lower lung capacity in females than males<sup>7)</sup>. This particular finding indicates that the difference in lung function values between Saudi male and female subjects cannot be fully explained only on the basis of previously described sex-based differences in lung anatomy<sup>21)</sup> and respiratory function<sup>6)</sup>. This difference might be due to smaller height of the female subjects of this study, as the height of the subject can have an effect on pulmonary function parameters<sup>22)</sup>. In addition, the face veil traditionally used by Saudi women may possibly have had an effect on the results of this study; this aspect, i.e., the effect of face veil on pulmonary function, merits a detailed study.

Previous research has suggested a positive relationship

between levels of physical activity and pulmonary function<sup>11,12</sup>). It has been shown that an increase in physical activity can improve the fitness of the cardio-respiratory system<sup>23</sup>), and this can be attributed to an increase in the strength of the respiratory muscles<sup>24</sup>). Higher physical activity has been shown to be related to a slower age-related decline in pulmonary function<sup>25</sup>). It was shown that an increase in physical activity was closely related to enhancing the FEV1 values in a group of men aged 71–93 years<sup>26</sup>). In another study it was found that changes in physical activity were closely associated with changes in FVC in adolescents aged 13–27 years<sup>27</sup>). Furthermore, another study showed that subjects who perform a vigorous form of physical activity and climb more stairs have a slower rate of age-related decline in FEV1 than subjects who are physically inactive<sup>28</sup>).

Taken together, it is reasonable to speculate that the greater difference in lung function parameters between the Saudi females and males in this study than previously reported sex-based differences in lung function<sup>6</sup>), might be due to the relatively high prevalence of physical inactivity among Saudi adults, especially females<sup>13</sup>). According to the results of our study, Saudi females generally engage in moderate physical activity, while males engage more in vigorous physical activity. This is in accordance with the general observation that in Saudi society, traditionally the females of all ages are not generally encouraged to participate in physical activities, particularly in heavy or vigorous physical activities. For this reason, the physical activity score (MET-minutes/week) was evaluated for all subjects using the International Physical Activity Questionnaire (IPAQ), which is a reliable and valid method for monitoring physical activity levels among adults of different ages<sup>29</sup>). The data of this study show that the physical activity score (MET-minutes/week) of males was significantly higher than that of the female subjects. The test used to determine the relationship between pulmonary parameter values and physical activity score of subjects of either gender did not show any significant correlation. However, it is interesting to note that at group level (males and females), the values of pulmonary function parameters were related to physical activity score (MET-minutes/week), i.e., higher pulmonary function parameters and higher physical activity score as for males, and lower pulmonary function parameters and lower physical activity score as for females.

In conclusion, our present results show that there are sex-based differences in lung function tests among Saudi adults, and values for males were higher than the values for females. This difference in lung function tests between genders is greater than the known anatomical differences in the respiratory systems of males and females. The Saudi males are more physically active than females but no significant correlation between pulmonary function parameters and physical activity score was found for either gender. Sports and work related physical activities should be encouraged within the Saudi community, especially for females to prevent a decline in their ventilatory functions.

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