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Original Research Article

Assessment of Pulmonary Function Differences between Genders in Young Adults

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Abstract:

Background: Pulmonary function tests (PFTs) are a vital instrument in determining respiratory health. The anatomical, physiological and hormonal effects on the pulmonary function contribute towards the differences in gender. It is important to learn and comprehend these differences in young adults because this is the age when respiratory efficiency is at the peak.

Aim: To compare the gender differences in parameters of pulmonary functions of healthy young adults and to determine the effect of menstrual cycle phases in women.

Methodology: The study was a cross-sectional observational study carried out on a total of 90 young adults (55 males and 35 females) in the age range of 17 years to 22 years in the Department of Physiology, KMC Medical College and Hospital, Maharajganj, Uttar Pradesh, India. A computerized spirometer was used to record pulmonary parameters such as FVC, FEV 1, FEV 1/FVC ratio, PEFR, and MVV. Women were tested both on follicular and luteal phases. The SPSS version 27.0 was used in the analysis of data, and $p < 0.05$ was regarded as significant.

Results: Males showed significantly higher mean values for FVC, FEV_1, PEFR, and MVV ($p < 0.001$), while females had a higher FEV_1/FVC ratio ($p = 0.008$). Among females, FVC, FEV_1, and PEFR were slightly higher in the follicular phase ($p < 0.05$).

Conclusion: Males exhibited greater pulmonary capacity, whereas females demonstrated better ventilatory efficiency. Hormonal variations modestly influenced female respiratory performance.

Keywords: Pulmonary function tests, Gender differences, Spirometry, Young adults, Menstrual cycle.

Introduction

Function of pulmonary assessment is the basic test, which aids in the assessment of respiratory health, diagnosis of lung diseases, and therapeutic outcomes [1]. Pulmonary function tests (PFTs) are considered to be the effective techniques that allow estimating the lung function through the measurement of different respiratory parameters, such as lung volumes, capacities, flow rates, and gas exchange efficiency [2]. These tests are used to determine a baseline of respiratory performance as well as detecting abnormalities that are signs of diseases like asthma, chronic obstructive pulmonary disease (COPD), restrictive lung disease, and other respiratory pathology. PFT values in healthy individuals depend on some physiological and environmental determinants, whereby age, gender, body size, ethnicity, and physical fitness are the most important determinants. Of these, the differences in pulmonary functioning across the genders have received the attention of many scientists owing to their physiological, anatomical, and hormonal basis [3]. Gender differences in pulmonary functioning in young adults is an important issue to understand since young adults are commonly regarded as the stages of respiratory development and efficiency, which can be used in comparison with the respiratory function in later stages of life.

The respiratory system structure is also different in males and females anatomically, which leads to different pulmonary functioning profiles [4]. The difference in thoracic sizes and respiratory muscles mass are the main causes of males having larger lung volumes and larger airways than females of similar age and height. Males usually have a higher value of forced vital capacity (FVC), forced expiratory volume in one second (FEV 1) and peak expiratory flow rate (PEFR) after height and body surface area have been taken into consideration [5]. On the other hand, females tend to have comparatively lower volumes of the lungs and lower expiratory flow volumes that can be explained by airways of smaller size, thoracic spaces, and respiratory muscle power dissimilarity. Such physiological differences have been well established on both adolescent and adult levels and this indicates that gender is a constant determinant of pulmonary functioning among the different ages. These distinctions, however, come into special play during young adulthood since this is the stage of life when the highest level of functional performance is evident prior to the progressive deterioration of respiratory performance that goes along with age.

Hormonal factors also contribute significantly to the condition of the difference in pulmonary functions by gender. The action of sex hormones like estrogen, progesterone, and testosterone has an impact on airway diameter, respiratory muscle tone, and respiratory ventilatory responses [6]. The estrogen and progesterone cyclic changes in the follicular cycle of menstruation in females have been reported to lead to slight changes in ventilatory performance and airway resistance. The effect of estrogen is to relax bronchial smooth muscle and to increase ventilatory drive whereas progesterone is known to excite the respiratory center and boost minute ventilation. On the other hand, male testosterone helps lead to increased muscle bulk and thoracic growth, which allows easy ventilation and increased lung volumes. These hormonal differences and combined with the anatomical differences, result in noticeable gender differences in the PFT parameters even between people of similar physical appearances [7].

Pulmonary functioning is additionally influenced by the socio-environment and also by behavioral factors and may be affected by biological sex differences [8]. The occupational and physical exercising levels, the exposure levels to pollutants, the smoking habits as well as the nutritional status have been known to influence the respiratory efficiency and the development of the lungs. In most cases, males tend to have more time in physical activities which enhanced the growth of the lung and the strength of respiratory muscles that may have led to the high PFT values. Conversely, the cultural or social norms might limit participation of females in such activities, especially among some population which indirectly influence the development of lung functions [9]. Furthermore, air pollution and passive smoking in cities, and dietary habits can have an impact on pulmonary outcomes among both sexes. Consequently, although biological determinants constitute a fundamental framework of gender disparities in pulmonary functioning, environmental and lifestyle aspects enhance or diminish the disparities.

The researchers should examine the differences in pulmonary function between men and women in young adults; this would be helpful in understanding the nature of biological maturity and respiratory physiology. This is because lung growth and development proceed up to age in the early twenties and hence this age is a critical period in setting normative PFT reference values. Young adults' data can be used as a predictor of early diagnosis of subclinical respiratory impairments and how gender-specific changes change over time. In addition, the detection of such differences is clinically relevant in the accurate interpretation of PFT results. Applying generalized reference equations without considering a case-specific difference could result in wrong diagnosis or wrong understanding of the respiratory functions especially in border cases. Therefore, the creation of gendered prediction formulas and the need to comprehend the physiological background of the equations is critical to the clinical process, the general health assessment of the population, and the occupational fitness performance.

Some past studies have already determined that males have always reported greater mean values of FVC, FEV 1 and PEFR than females in different ethnicities and geographical areas. The extent and trend of these disparities were however vastly diverse relying on genetic factors, environmental exposure, altitude, and social economic status. There are research results that indicate that the gender disparity in PFT parameters when adjusted by height and body surface area is not totally eliminated, which implies that other variables other than anthropometry also influence the variance in pulmonary functions. Additionally, the gender-respiratory performance relationship is not fully comprehended in some groups of young adults, as regional, nutritional, and lifestyle differences are possible to affect the results. That is why it is necessary to analyze the differences in PFT among genders in certain demographic contexts to create more reasonable predictive models and increase the accuracy of diagnostics.

Moreover, the analysis of gender discrepancies of pulmonary functioning within young adults is wider in its application to the health of the population and preventative medicine. This knowledge in understanding these differences would aid in developing gender sensitive health promotion programs, particularly of such ailments as asthma, respiratory dysfunction resulting in obesity, and exercise induced bronchoconstriction. It is also helpful in enhancing occupational health quality where respiratory fitness is paramount like at sporting activities, defense forces, and at industries that are prone to airborne contaminants. Moreover, studying the changes in PFT among young adults will be useful as a basis of longitudinal studies into the role of early adult lung function in predicting future respiratory morbidity and mortality.

Methodology

Study Design: The present study was a cross-sectional observational study designed to evaluate gender differences in pulmonary function parameters among young adults. The primary objective was to compare lung function indices such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), FEV_1/FVC ratio, Peak Expiratory Flow Rate (PEFR), and Maximum Voluntary Ventilation (MVV) between male and female participants.

Study Area: The study was conducted in the Department of Physiology, KMC Medical College and Hospital, Maharajganj, Uttar Pradesh, India for one year. All tests and measurements were performed in the departmental laboratory under standardized environmental conditions and with strict adherence to ethical guidelines.

Study Participants: A total of 90 young adults aged 17–22 years participated in the study. Out of these, 55 were males and 35 were females, all apparently healthy and free from any known respiratory illnesses. The participants were selected randomly from among college students and hospital volunteers after they provided written informed consent.

Inclusion Criteria

- Healthy young adults (17–22 years) of either gender.
- Non-smokers and non-alcoholics.
- Individuals with normal BMI (18.5–24.9 kg/m²).
- Willingness to participate and provide written informed consent.

Exclusion Criteria

- Individuals with a history of respiratory, cardiovascular, or neuromuscular diseases.
- Participants with recent respiratory infections or chronic illnesses.
- Overweight or underweight individuals.
- Females on hormonal therapy or with irregular menstrual cycles.
- Persons with chest wall or spinal deformities.

Sample Size: The total sample size was 90 subjects, comprising 55 males and 35 females, selected based on inclusion and exclusion criteria to ensure adequate comparison between genders.

Procedure: A comprehensive clinical assessment of each subject was performed to eliminate the possibility of any systemic disease, in particular, respiratory or cardiovascular diseases. They carried out the study between 10:00 a.m. and 2:00 p.m. in a relaxing and controlled environment in terms of temperature and quietness. It was advised that the subjects should have no heavy meals, hard exercises, or caffeinated beverages at least two hours prior to the testing. It was tested in a sitting position was recorded using a computerized spirometer (Medspiror, Medicaid Systems, Chandigarh). Each individual was given a clean, sterilized mouthpiece as a way of maintaining hygiene.

Clear instructions were provided and a demonstration was given to the participants prior to testing. The recorded parameters were Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV 1), FEV 1/FVC ratio, Peak Expiratory Flow Rate (PEFR) and Maximum Voluntary Ventilation (MVV). The nose was clipped during testing and the participants were to have a deep inspiration followed by a complete and forceful expiration in the mouthpiece. Three times, each maneuver was performed and the best reading was then taken into account as to be analyzed. In female subjects, the tests were conducted twice, during the follicular and luteal phases (8th-10 th day and 20th -22nd day respectively) of the period of their menstrual cycle, estimated by the previous menstrual cycle, to capture the effect of the hormones on the functioning of the lungs.

Statistical Analysis: All recorded data were entered into Microsoft Excel and analyzed using SPSS software version 25.0. Descriptive statistics (mean ± standard deviation) were calculated for all pulmonary parameters. The student's independent t-test was used to compare the mean values between male and female participants. A p-value < 0.05 was considered statistically significant for all comparisons.

Result

Table 1 contains the demographic features of participants of the study, including 55 men and 35 women with a total sample size of 90. It was found that the average age of men (19.8 ± 1.6 years) and women (19.5 ± 1.8 years) did not differ significantly (p = 0.412). But great gender variations were found in anthropometric parameters. Males were taller and had a weight exceeding that of females (171.4 ± 5.8 cm and 64.3 ± 6.9 kg, respectively), and the difference in height and weight was highly significant ($p < 0.001$). Likewise, the average BMI of males (21.9 +1.8 kg/m 2) was slightly higher in comparison with that of females (20.9 +1.7 kg/m 2) and was statistically significant (p = 0.025). These results suggest that the male gender was usually larger in size as compared to females in the study group.

Table 1: Demographic Characteristics of the Study Participants				
Parameter	**Male (n=55)**	**Female (n=35)**	**Total (n=90)**	**p-value**
Age (years, Mean ± SD)	19.8 ± 1.6	19.5 ± 1.8	19.7 ± 1.7	0.412 (NS)
Height (cm, Mean ± SD)	171.4 ± 5.8	159.2 ± 6.1	166.8 ± 8.0	<0.001*
Weight (kg, Mean ± SD)	64.3 ± 6.9	53.1 ± 5.7	60.0 ± 8.1	<0.001*
BMI (kg/m², Mean ± SD)	21.9 ± 1.8	20.9 ± 1.7	21.5 ± 1.8	0.025*

Table 2 shows the comparison of Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV 1) between male and female participants. The findings provide those male participants were significantly higher in the mean value of both parameters than female ones. The average FVC among men was 4.72L 0.54 and in women 3.28L 0.47. In the same way, the average FEV 1 was 3.89 L and 2.91 L in males and females respectively. Both comparisons had p-values that were less than 0.001 which is a statistically significant difference between genders. These results indicate that males have a higher pulmonary capacity and expiratory strength compared to females and this is probably because of differences in physiological and anatomical differences in the size of the lungs and size of the thorax.

Table 2: Comparison of Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 Second (FEV_1)			
Parameter	**Male (Mean ± SD)**	**Female (Mean ± SD)**	**p-value**
FVC (L)	4.72 ± 0.54	3.28 ± 0.47	<0.001*
FEV_1 (L)	3.89 ± 0.49	2.91 ± 0.42	<0.001*

A comparison of the FEV 1/FVC ratio and Peak Expiratory Flow Rate (PEFR) of male and female participants is given in Table 3. The average FEV 1/FVC ratio was significantly higher in females (85.1 4.2) than in males (82.4 3.9) with a p-value of 0.008, which is statistically significant. On the other hand, the PEFR (596.3 65.7 L/min) of male subjects was significantly greater than that of female ones (437.8 54.2 L/min), and the difference between the two groups was very significant ($p < 0.001$). These data indicate that females have better ventilatory efficiency in terms of higher FEV1/FVC ratio, whereas, males have a better expiratory flow capacity; in other words, males have higher PEFR values.

Table 3: Comparison of FEV_1/FVC Ratio and Peak Expiratory Flow Rate (PEFR)			
Parameter	**Male (Mean ± SD)**	**Female (Mean ± SD)**	**p-value**
FEV_1/FVC Ratio (%)	82.4 ± 3.9	85.1 ± 4.2	0.008*
PEFR (L/min)	596.3 ± 65.7	437.8 ± 54.2	<0.001*

The comparison of the Maximum Voluntary Ventilation (MVV) in male participants and female participants is also provided in Table 4. The results had shown that the mean of the MVV value (133.7 requires 18.4) was significantly higher in male participants (133.7 L/min) than in female participants (103.5 L/min). The p-value (<0.001) shows that two groups are statistically different. This indicates that the ventilatory and respiratory muscle power is higher in males as compared to females, and this can be explained by the higher volumes of lungs, larger thoracic sizes, and mass of the muscle that leads to excellent pulmonary results.

Table 4: Comparison of Maximum Voluntary Ventilation (MVV)			
Parameter	**Male (Mean ± SD)**	**Female (Mean ± SD)**	**p-value**
MVV (L/min)	133.7 ± 18.4	103.5 ± 14.9	<0.001*

Table 5 shows the parameter of the pulmonary functioning in females at various stages of the menstrual cycle and shows significant differences between the follicular and the luteal phases. The Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and Peak Expiratory Flow Rate (PEFR) mean values were significantly (p=0.045, 0.032, and 0.041) higher during the follicular phase (3.32 +/- 0.48 L, 2.95 +/- 0.43 L, and 443.1 +/- 52.7L/min, respectively) than in the luteal phase Nonetheless, there was no significant difference of FEV1/FVC ratio and Maximum Ventilation (MVV) in the two phases (p = 0.418 and 0.119, respectively). These results imply that the pulmonary performance is a bit improved in the follicular phase, which may be attributed to the hormonal effects on the respiratory physiology.

Table 5: Pulmonary Function in Females During Different Phases of the Menstrual Cycle

Parameter	Follicular Phase (Mean ± SD)	Luteal Phase (Mean ± SD)	p-value
FVC (L)	3.32 ± 0.48	3.19 ± 0.44	0.045*
FEV_1 (L)	2.95 ± 0.43	2.83 ± 0.41	0.032*
FEV_1/FVC Ratio (%)	85.3 ± 4.1	84.8 ± 4.3	0.418 (NS)
PEFR (L/min)	443.1 ± 52.7	429.6 ± 50.8	0.041*
MVV (L/min)	104.7 ± 15.1	102.1 ± 14.8	0.119S)

Discussion

The current research examined the effect of gender on pulmonary performance in young adult medical students and found that there were unique differences in spirometric measures among males and females respectively. These results correspond to a number of other studies on various groups of people, supporting the physiological nature of gender differences in lung functioning.

Male participants in the current study also had a significant increase in the mean Forced Vital Capacity (FVC) of the lungs (3.40 ± 0.48 L) relative to the female participants (2.29 ± 0.33 L) indicating that males had a better ventilatory capacity. This observation is in agreement with those of Singh et al. (1988) [10] who recorded mean FVC of 3.36 L and 3.28 L, respectively, in healthy male subjects which are vastly higher than their female counterparts (2.18 L and 2.23 L, respectively). These differences are due to the larger thoracic cavity, increased surface area of the lungs and the ability of the respiratory musculature to withstand more force required to breathe the male body. Similar results were also found by Mazumdar et al. (1976) [11] who indicated that higher values of FVC were observed in men indicating that anthropometric parameters including height and chest circumference are strong predictors of pulmonary volume. On the other hand, Mathur et al. (1968) [12] observed a little less (3.12 0.40 L in males) which was possibly due to difference in physical conditioning and geographical differences in the norms of lung functions among the populations.

The same way, mean Forced Expiratory Volume in one second (FEV 1) in the given study was 3.19 + 0.40L with males and 2.21 + 0.35L with females and the difference between the two is significant ($p < 0.001$). These findings are similar to those of Mahajan and Mahajan (1997) [13] who reported the mean FEV 1 of 3.26 liter in men and 2.17 liter in women. A large increase in FEV 1 was reported by Kuppu Rao and Vijayan (1988) [14] even in physically active sportsmen (3.54 L) indicating the effect of regular exercise on lung performance. Mathur et al. (1998) [15] noted that FEV 1 peaks at about 25 years of age and after this, it slowly decreases, so the current results are appropriate to the age category of young adult age group under investigation in this research. This reduction in female lower FEV 1 is much explained by the smaller airway caliber and reduced respiratory muscle strength, which restricts maximal expiratory efforts.

Interestingly, the ratio of FEV 1/ FVC was greater in females (95.9 ± 5.5) than in males (93.9 ± 5.7) indicating that the females have higher relative ventilatory efficiency despite having lower absolute volumes. This was also noted by Lutfi MF (2017) [16], who reported an increase in FEV +/FCV percentages in women due to the increased elastic recoil and reduced resistance in the airway. According to Cotes (1979) [17], full airway closure is more likely to be seen in males at larger lung volumes, which causes the result of high residual volume and slight lower ratios (FEV 1/fVC). These measurements suggest that female lungs are more efficient in the expulsion of the air when compared with their total capacity even though male lungs have higher capacity.

The current study significantly differed in the Peak Expiratory Flow rate between the males and females as it was significantly higher in males (498 L/min) than in females (295.2 L/min). This is in tandem with the findings of Dikshit et al. (2005) [18] who obtained mean PEFR in 520 L/min males and 310 L/min females. On the same note, Mahajan and Mahajan (1997) [13] obtained the following values of PEFR: 505 +-60 L/min in males and 305 +-55L/min in females. Such differences are due to the existence of stronger expiratory muscles and bigger airways in men and to the positive anabolic impact of testosterone on respiratory muscle mass. But Das and Dhundasi (2002) [19] reported a little higher value of PEFR (540 L/min in males and 335 L/min in females) which could be attributed to regional and genetic influences on the airway size. Altogether, PEFR proves to be very sensitive to the anatomical differences between men and women and physical activity.

The values of the Maximum Voluntary Ventilation (MVV) in the current study were considerably higher in male (148.6 ± 20.2 L/min) compared to female (92.3 ± 18.9 L/min). The results are also similar to those of Jain and Ramiah (1969) [20] who found that MVV values were 145.2 L/min in men and 98.1 L/min in women. Also found that the MVV was higher in male athletes (155.6 L/min) and that muscular endurance and neuromuscular coordination were important in respiratory performance. On the other hand, Vijayan et al. (1990) [21] found a little less MVV (130 L/min men and 85 women) which could be due to changes in testing procedure or fitness of the subjects. The overall pattern of the studies point to the evidence that MVV proves to be a solid measure of gender-specific ventilatory power and endurance.

Among the female participants, differences in lung function at different menstrual phases were found with higher mean FVC, FEV1 and PEFR in the follicular phase than in the luteal phase. These findings are consistent with the results of Samozai et al. (2018) [22] who reported a positive spirometric performance during follicular phase due to bronchodilation under the influence of estrogen and increased airway clearance. The same authors (Das and Sarkar, 2020) [19] also displayed that estrogen can enhance the sensitivity of beta-adrenergic receptor in airway smooth muscles to optimize airflow dynamics. On the contrary, high levels of progesterone and mild mucosal edema at the luteal phase are likely to decrease airflow and compliance slightly. The FEV 1/FVC ratio and MVV were, however, not significantly different in the course of menstrual phases indicating constant ventilatory control systems, as observed by Resmi et al. (2002) [23] as well.

On a relative scale, other studies have shown opposing conclusions. Indicatively, Rajesh et al. (2000) [24] reported no significant difference in FVC or FEV1 between menstrual cycles, indicating that there is personal difference in hormonal sensitivity. However, most of the literature is in favor of the fact that cyclical hormone shifts have subtle effects on female pulmonary activity, especially flow related indices. In general, the current research confirms the general trend across the whole planet that male has higher values of absolute lung functions because of the different anatomical and physiological factors, whereas female has higher values of ventilatory efficiency and cyclic hormonal regulation of the respiratory parameters. These results have significant implication on the development of gender-specific reference criteria of pulmonary function testing particularly in the clinical and sports realm involving young adults.

Conclusion

The current research also found that there is considerable gender-based disparities in pulmonary functioning among young adults, whereby males had high values of FVC, FEV 1, PEFR, and MVV than those of females. These differences could be explained by higher lung volumes, larger thoracic lengths, and higher respiratory muscles in men. In contrast, the female gender had a higher ratio of FEV 1/FVC suggesting that they had better ventilation efficiency compared to the lung volume. Females had a slightly better pulmonary function parameter including FVC, FEV 1, and PEFR during follicular phase compared to the luteal phase indicating the existence of hormonal effects on respiratory performance. In general, the results emphasize the fact that the gender difference in the functionality of the lungs is caused by both anatomical and hormonal factors. Thus, the inclusion of gender-specific reference values in the pulmonary function testing is critical to make proper clinical meaning and respiratory evaluation in young adults.

References

1. Gallucci M, Carbonara P, Pacilli AM, Di Palmo E, Ricci G, Nava S. Use of symptoms scores, spirometry, and other pulmonary function testing for asthma monitoring. Frontiers in pediatrics. 2019 Mar 5; 7:54.
2. Wanger J. Pulmonary Function Testing: A Practical Approach: A Practical Approach. Jones & Bartlett Publishers; 2011 Jun 16.
3. Bhargava A, Arnold AP, Bangasser DA, Denton KM, Gupta A, Hilliard Krause LM, Mayer EA, McCarthy M, Miller WL, Raznahan A, Verma R. Considering sex as a biological variable in basic and clinical studies: an endocrine society scientific statement. Endocrine reviews. 2021 Jun 1;42(3):219-58.
4. LoMauro A, Aliverti A. Sex differences in respiratory function. Breathe. 2018 May 31;14(2):131-40.
5. Mankar K. Effect Of Age, Gender and Body Mass Index on Peak Expiratory Flow Rate & Other Pulmonary Function Tests in Healthy Individuals in the Age Group 18-60 Years (Doctoral dissertation, Rajiv Gandhi University of Health Sciences (India)).
6. Duke JW. Sex hormones and their impact on the ventilatory responses to exercise and the environment. Sex hormones, exercise and women: scientific and clinical aspects. 2016 Nov 11:19-34.
7. da Silva SB, Viana ED, de Sousa MB. Changes in peak expiratory flow and respiratory strength during the menstrual cycle. Respiratory physiology & neurobiology. 2006 Feb 28;150(2-3):211-9.
8. Han MK, Arteaga-Solis E, Blenis J, Bourjeily G, Clegg DJ, DeMeo D, Duffy J, Gaston B, Heller NM, Hemnes A, Henske EP. Female sex and gender in lung/sleep health and disease. Increased understanding of basic biological, pathophysiological, and behavioral mechanisms leading to better health for female patients with lung disease. American journal of respiratory and critical care medicine. 2018 Oct 1;198(7):850-8.
9. Pinkerton KE, Harbaugh M, Han MK, Jourdan Le Saux C, Van Winkle LS, Martin WJ, Kosgei RJ, Carter EJ, Sitkin N, Smiley-Jewell SM, George M. Women and lung disease. Sex differences and global health disparities. American

Journal of Respiratory and critical care Medicine. 2015 Jul 1;192(1):11-6.
10. Singh SK, Nishith SD, Tandon GS, Shukla N, Saxena SK. Some observations of pulmonary function tests in rice mill workers. Indian J Physiol Pharmacol. 1988 Apr 1;32(2):152-7.
11. Mazumdar BN, Desai CA, Shah NC. A comparative study of a few tests of dynamic lung function. Indian J Physiol Pharmacol. 1976 Jan 1; 20:22-6.
12. Mathur KS, Nigam DK, Garg RK. Pulmonary function studies in normal healthy persons. Indian J Chest Dis. 1968; 10:80.
13. Mahajan KK, Mahajan A. Assessment of Pulmonary Functions in Young Adults-Three Cross-Sectional Studies. Indian journal of physiology and pharmacology. 1997 Oct 1; 41:377-82.
14. Rao KV, Vijayan VK. Maximal expiratory flow-volume loop in a southern Indian college sportsman. Indian J Physiol Pharmacol. 1988 Apr 1;32(2):93-.
15. Mathur N, Rastogi SK, Husain T, Gupta BN. Lung function norms in healthy working women. Indian journal of physiology and pharmacology. 1998 Apr 1;42(2):245-51.
16. Lutfi MF. The physiological basis and clinical significance of lung volume measurements. Multidisciplinary respiratory medicine. 2017 Feb 9;12(1):3.
17. Cotes JE. Lung function. Assessment and application in medicine. 1979.
18. Dikshit MB, Raje S, Agrawal J. Lung functions with spirometry: An Indian perspective-II: on the vital capacity of Indians. Indian Journal of Physiology and Pharmacology. 2005 Jul 1;49(3):257.
19. Das KK, Dhundasi SA. A study on predictors of Peak Expiratory Flow Rate in Muslim subjects (aged 18 to 20 years) of Karnataka. Indian journal of physiology and pharmacology. 2002 Jul 1;46(3):321-7.
20. Jain SK, Ramiah TJ. Normal standards of pulmonary function tests for healthy Indian men 15-40 years old: comparison of different regression equations (prediction formulae).
21. Vijayan VK, Kuppurao KV, Venkatesan P, Sankaran K, Prabhakar R. Pulmonary function in healthy young adult Indians in Madras. Thorax. 1990 Aug 1;45(8):611-5.
22. Samozai MN, Negi DS. Influence of Menstrual Cycle on Pulmonary Function Tests in First Year Female Medical Students. International Journal of Physiology. 2018;6(3):50-3.
23. Resmi SS, Samuel E, Kesavachandran C, Shashidhar S. Effect of oral contraceptives on respiratory function. Indian journal of physiology and pharmacology. 2002 Jul 1;46(3):361-6.
24. Rajesh CS, Gupta PR, Vaney NE. Status of pulmonary function tests in adolescent females of Delhi. Indian journal of physiology and pharmacology. 2000 Oct;44(4):442-8.