Evaluation of pulmonary function tests in elderly population

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Abstract

Background: An understanding of age-related changes in the respiratory functions is important.

Objective: To evaluate the pulmonary function tests (PFTs) in elderly population and to construct prediction equations for them.

Material and Methods: PFTs were performed on 185 healthy, non-smoker (115 male and 70 female) subjects aged 60 years and above. They were divided into 4 groups: Group I (60–64 years), Group II (65–69 years), Group III (70–74 years) and Group IV (75 years and above).

Results: There was progressive decline in mean values of body weight (wt) and body surface area (BSA) with increase in age ($p < 0.001$). Forced vital capacity (FVC), forced expiratory volume in half second ($FEV_{0.5}$), forced expiratory volume in 1 second (FEV_1), forced expiratory volume in 3 seconds (FEV_3), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV) showed a significant decrease in their mean values in all groups. Prediction equations for estimating mean values of FVC, FEV_1, and PEFR were constructed.

Conclusion: Aging is associated with significant reduction in PFT values.

KEY WORDS: Ageing, PFTs, FVC, PEFR, MVV, prediction equation

Introduction

Ageing is associated with progressive decline in functional reserve of body organs. There is a variation in physiological measures among older adults, necessitating the defining of population-specific "normal" limits and to differentiate the normal from a diseased state.[1] Such differentiation is vital in a clinical setting.

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Pulmonary function tests (PFTs) assess the functional status of respiratory system. There have been only a few studies to establish reference standards for pulmonary function with age, especially among Indian population.[2] Scan of literature failed to reveal any studies conducted on pulmonary function in the elderly in our part of the country. Therefore, the present study was undertaken.

Material and Methods

The present study was undertaken on elderly (60 years and above) healthy, non-smoker subjects of both sexes enrolled from Old Age Homes located within Jammu city after seeking due permission from their administrators.

Subjects with abnormalities of vertebral column and thorax; severe anaemia, hypertension, diabetes mellitus, pulmonary disorders, URTI, smokers, tobacco chewers, and those with history of abdominal or chest surgery were excluded.

In total, 300 subjects were screened and 185 subjects who fulfilled the eligibility criteria were enrolled for the study. A written informed consent was obtained. The subjects were divided into four age groups as per their age: Group I (60–64 years), Group II (65–69 years), Group III (70–74 years) and Group IV (75 years and above).

The study was carried out in the Department of Physiology, Government Medical College, Jammu and it was cleared by Institutional Ethics Committee vide letter no. pharma/2010/286 dated 22 June, 2010.

Following parameters were noted for each subject:

Age: Age was recorded in years as on the previous or next birthday which ever was nearer as per the records/statement of the individual.[3]

Weight (kg): Platform beam balance (Krupas) was used to record the weight. Height was recorded to the nearest centimeter. Body surface area (BSA) was calculated from Nomogram in square meters (m^2). Respiratory rate was counted for full one minute.[4]

PFTs were performed with the help of Medspiror (RMS). Prior to the test, the subjects were fully assured and familiarized with the apparatus.

Three readings were taken at same time of the day between 11:00 AM to 1:00 PM, after a light breakfast in the morning. Tests were done in sitting position and best of the three readings was selected.

Only two maneuvers, *i.e.*, forced vital capacity (FVC) and MVV are required to be performed to gather all the necessary data. Following parameters were calculated: FVC, forced expiratory volume in half second ($FEV_{0.5}$), forced expiratory volume in 1 second (FEV_1), forced expiratory volume in 3 seconds (FEV_3), peak expiratory flow rate (PEFR), mean forced expiratory flow rate from 0.2 to 1.2 liters of volume change ($FEF_{0.2-1.2}$), mean forced expiratory flow during middle half of FVC ($FEF_{25-75\%}$), forced expiratory flow 25% ($FEF_{25\%}$), forced expiratory flow 50% ($FEF_{50\%}$), forced expiratory flow 75% ($FEF_{75\%}$), $FEV_{0.5}$/FVC, FEV_1/FVC, FEV_3/FVC, and maximum voluntary ventilation (MVV).

Statistical Analysis

The data were analyzed using Microsoft Excel, SPSS version 12.0 for Windows and Epi-Info version 6.1. Mean and standard deviation (SD) were calculated. Statistical difference in mean values was tested using ANOVA (Analysis of Variance). A *p*-value of < 0.05 was considered statistically significant.

Results

Compared to Group I, there was progressive decline in body weight with advancing age in Groups II, III, and IV; and the difference was significant in both male and female subjects (*p*-value < 0.0001). Mean values of height among the subject population were similar. Mean body surface Area of the subjects showed a significant (*p*-value < 0.0001) decline among subjects across different age groups.

Respiratory rate was almost similar in the subjects ($p > 0.05$) (Tables 1–4).

There was progressive decline in mean values of FVC, $FEV_{0.5}$, FEV_1, FEV_3 from Group I to Group IV in both males and females and the difference was statistically significant ($p < 0.0001$).

The estimated prediction equation for FVC (L) was: for females = 3.668 + 0.01 (height) − 0.059 (age) and for males was = 0.029 (height) − 0.0458 (age) + 0.643; for FEV1 (L) was: for females = 3.644 − 0.055 (age) + 0.0086 (ht) and for males was = 0.836 − 0.037 (age) + 0.020 (height). The value of FEV1, as calculated from prediction equation in females was 1.171 liters (mean age 67.6: mean height 154.614) and in males 1.529 liters (mean age 70.31; mean height 163.6). Prediction equation for the FEV3 (L) in females was 1.637 − 0.056 (age) + 0.024 (height) and in males 1.085 − 0.045 (age) + 0.026 (height).

For PEFR (L/s), the prediction equation formulated for females was 9.249 − 0.175 (age) + 0.035 (height) and in males was 12.73 − 0.137 (age) + 0.002 (height).

Expiratory flow rates, viz., $FEF_{2-1.2}$, $FEF_{25-75\%}$, $FEF_{25\%}$, $FEF_{50\%}$, and $FEF_{75\%}$ varied significantly between different age groups and decline was significant in both male and female elderly subjects ($p < 0.001$).

Discussion

Ageing, a universal phenomenon, is not a disease but there occurs general decline, first in functional reserve, then

Table 1: Anthropometric data of the subjects

	Group 1 (60–64 years)		Group 2 (65–69 years)		Group 3 (70–74 years)		Group 4 (≥ 75 years)	
	Male (*n* = 36)	Female (*n* = 27)	Male (*n* = 24)	Female (*n* = 20)	Male (*n* = 28)	Female (*n* = 13)	Male (*n* = 27)	Female (*n* = 10)
Weight (kg)	65.77 ± 9.50	64.40 ± 11.80	59.42 ± 10.08****	53.90 ± 9.92^^^^	56.89 ± 8.97****	49.53 ± 8.10^^^^	49.62 ± 7.06****	46.80 ± 7.34^^^^
Height (cm)	166.44 ± 5.27	156.51 ± 6.89	166.95 ± 5.33	155.45 ± 5.66	164.14 ± 4.44	151.15 ± 4.14	163.92 ± 6.02	153.60 ± 5.50
BSA (m2)	1.72 ± 0.13	1.64 ± 0.16	1.67 ± 0.13****	1.51 ± 0.13^^^^	1.62 ± 0.13****	1.43 ± 0.10^^^^	1.52 ± 0.11****	1.42 ± 0.13^^^^

**** $p < 0.0001$, ^^^^ $p < 0.0001$.

Table 2: Respiratory rate, FVC and FEV of all groups

	Group 1 (60–64 years)		Group 2 (65–69 years)		Group 3 (70–74 years)		Group 4 (≥ 75 years)	
	Male (*n* = 36)	**Female (*n* = 27)**	**Male (*n* = 24)**	**Female (*n* = 20)**	**Male (*n* = 28)**	**Female (*n* = 13)**	**Male (*n* = 27)**	**Female (*n* = 10)**
RR (/min)	16.3 ± 1.76	16.7 ± 1.76	16.8 ± - 1.92	17.5 ± 1.76	17.2 ± 1.64	17.5 ± 0.96	17.5 ± 2.04	18.1 ± 1.57
FVC (L)	2.89 ± 0.58	2.00 ± 0.37	2.22 ± 0.61****	1.58 ± 0.32^^^^	1.88 ± 0.44****	1.25 ± 0.48^^^^	1.55 ± 0.37****	0.81 ± 0.23^^^^
FEV0.5	1.35 ± 0.65	1.16 ± 0.42	1.08 ± 0.38****	0.79 ± 0.28^^^^	0.67 ± 0.34****	0.43 ± 0.12^^^^	0.58 ± 0.2****9	0.44 ± 0.18^^^^
FEV1	2.06 ± 0.56	1.58 ± 0.42	1.73 ± 0.52****	1.17 ± 0.39^^^^	1.15 ± 0.47****	0.74 ± 0.18^^^^	1.01 ± 0.39****	0.60 ± 0.32^^^^
FEV3	2.77 ± 0.39	1.93 ± 0.45	2.21 ± 0.60****	1.56 ± 0.30^^^^	1.85 ± 0.43****	1.09 ± 0.21^^^^	1.46 ± 0.37****	0.82 ± 0.23^^^^
FEV0.5/FVC%	47.30 ± 23.19	59.41 ± 18.87	48.89 ± 11.35*	52.33 ± 19.69	37.36 ± 18.07*	47.40 ± 12.15	38.04 ± 17.43*	51.95 ± 20.25
FEV1/FVC%	78.14 ± 20.15	79.92 ± 15.85	76.50 ± 9.52	76.19 ± 19.34	64.95 ± 20.96	71.96 ± 17.42	61.76 ± 20.39	72.70 ± 22.21
FEV3/FVC%	97.09 ± 8.66	98.54 ± 1.64	99.63 ± 0.86	99.52 ± 1.31	98.80 ± 2.33	93.69 ± 18.77	94.49 ± 12.45	97.84 ± 7.38

* $p < 0.05$, ^^^ $p < 0.001$, *** $p < 0.001$, ^^^^ $p < 0.0001$.

Table 3: Respiratory flow rates of all groups

	Group 1 (60–64 years)		Group 2 (65–69 years)		Group 3 (70–74 years)		Group 4 (≥ 75 years)	
	Male (*n* = 36)	**Female (*n* = 27)**	**Male (*n* = 24)**	**Female (*n* = 20)**	**Male (*n* = 28)**	**Female (*n* = 13)**	**Male (*n* = 27)**	**Female (*n* = 10)**
FEF0.2–1.2	3.86 ± 1.44	2.81 ± 1.15	2.15 ± 0.79***	1.20 ± 0.74^^^	1.43 ± 0.83***	O.34 ± 0.66^^^	1.11 ± 0.82***	0.07 ± 0.19^^^
FEF25–75	2.75 ± 0.96	2.25 ± 0.69	1.80 ± 0.51***	1.41 ± 0.52^^^	1.31 ± 0.52***	0.79 ± 0.38^^^	1.05 ± 0.59***	0.71 ± 0.3^^^1
FEF25	4.53 ± 1.90	3.70 ± 0.94	2.81 ± 0.84***	2.33 ± 0.96^^^	2.19 ± 0.90***	1.25 ± 1.14^^^	1.58 ± 0.80***	0.93 ± 0.44^^^
FEF50	3.30 ± 1.28	2.89 ± 0.84	1.92 ± 0.61***	1.56 ± 0.75^^^	1.58 ± 0.90***	0.99 ± 0.77^^^	1.10 ± 0.66***	0.55 ± 0.43^^^
FEF75	1.58 ± 0.57	1.23 ± 0.43	1.01 ± 0.24***	0.86 ± 0.29^^^	0.95 ± 0.54***	0.50 ± 0.21^^^	0.63 ± 0.42***	0.54 ± 0.18^^^
PEFR (L/sec)	5.18 ± 1.80	4.23 ± 1.09	3.42 ± 1.21****	2.65 ± 1.01^^^	2.51 ± 1.02****	1.45 ± 0.90^^^	1.91 ± 0.85****	1.14 ± 0.44^^^^
MVV (L/Min)	71.45 ± 26.65	52.72 ± 19.15	48.76 ± 14.49****	23.66 ± 1.79^^^^	41.27 ± 14.66****	21.60 ± 6.30^^^^	24.15 ± 5.34****	18.97 ± 4.21^^^^

*** $p < 0.001$, ^^^ $p < 0.001$, **** $p < 0.0001$, ^^^^ $p < 0.0001$.

in function over time and the risk of developing disease is increased.[5]

The present study was an attempt to assess effects of increasing age on lung function parameters.

The lung matures by age 20–25 years, and thereafter aging is associated with progressive decline in lung function. The decline in PFTs depends on peak lung function achieved during adulthood.[1] Studies have demonstrated that age-related functional changes in the respiratory system result from: decrease in compliance of the chest wall, strength of respiratory muscles and elastic recoil of the lung.[6]

In the current study, there was a progressive decline in FVC, $FEV_{0.5}$ and FEV_1 (Table 2). These findings are in agreement with various earlier reports showed highest negative correlation of age with FEV0.5 and reported loss of 24 ml/year with ageing.[7–12]

However, our results are in disagreement with a study conducted by Woo and Pang[13] who reported that there was no age-related decline in FVC and FEV_1 in males aged 60 years and above.

The values of FVC and FEV_1 in present study were lower than the values derived from previous prediction equations.[14–16] Griffith et al[17] reported that healthy men lose lung function at a faster rate compared to healthy women and this is in disagreement with our result of loss of 37 ml/year for men and 55 ml/year for women. This disparity could be due to factors like weakening musculature and nutritional deficiency in Indian females.

Age is a significant predictor of lung function decline, with larger decrements of FEV_1 associated with greater age.[18] The mean value of FEV_3 in females was 1.514 liters (mean age 67.6: mean height 154.614) and in males it was 2.128 liters (mean age 70.31; mean height 163.6) as calculated by prediction equation. No report has been cited in the literature regarding the effect of aging on this parameter.

PEFR, a function of the caliber of large airway, is abnormally decreased only in moderate to severe airway obstruction.[19] In the present study, progressive decline in the mean PEFR value with increasing age was observed. Our observations were in agreement with a number of authors.[8,20–23]

Babb and Rodarte[24] have reported that mean bronchiolar diameter decreases after the age of 40. This decline may contribute to the decrement in expiratory flow noted with aging noted by Niewohnner et al.[25] In the aged lungs, the alveoli are enlarged and there is a mild degree of panacinar emphysema which causes air trapping in aged lungs.[26] The values of PEFR in the present study were considerably lower than the values calculated from the prediction equations in the study conducted by Enright et al.[27]

Expiratory flow rates are additional indices of airway resistance besides FEV1 and help in early diagnosis of airway obstruction especially when peripheral airways are involved. In the present study, there was progressive decline in mean values of $FEF_{0.2–1.2}$, $FEF_{25–75}$, and $FEF_{25\%}$ from Group I to Group IV in both males and females ($p < 0.0001$). Our findings were in agreement with various other reports.[6,12,13,18,19] However, our findings of intergroup comparison are in disagreement with Phatak et al[10] who reported that the decline in FEF25–75% was present only in females of Group IV.

FEV_1/FVC (%) ratio is more important index than FVC alone to categorizeventilatory abnormalities into obstructive or restrictive type. Mean FEV_1/FVC and FEV_3/FVC showed insignificant change in all groups but a significant decline in $FEV_{0.5}$/FVC was seen among male groups.

Similar observations have been reported previously.[8,19,26] However, a couple of studies[8,9] have reported that mean values of FEV1/FVC (%) remain fairly constant with aging in both genders.

MVV is a good guideline for the mechanical efficiency of lungs and measures the status of respiratory muscles, compliance of lungs and resistance offered by airways and tissues. MVV is more liable to both practice effects and fatigue effects.[28] In the present study, there was progressive decline in the mean value of MVV in subjects from Group I to Group IV in both males and females ($p < 0.00001$) and this is in agreement with those reported earlier.[10,21]

Age-related osteoporosis, reduced height of the thoracic vertebrae, stiffening of the thoracic cage from calcification of the rib cage and kyphosis reduce the ability of the thoracic cage to expand during inspiration and places the diaphragm at a mechanical disadvantage.[29]

Reduction in respiratory muscle functions and diaphragm strength predispose older individuals to diaphragmatic fatigue and ventilatory failure during increased ventilator load on the respiratory system.[30]

Starting around 50 years of age, alveolar ducts in humans increase in diameter due to degeneration of the elastic fibers around them. Reduction in supporting tissue results in closure of small airways during normal breathing, air trapping and hyperinflation, hence "senile emphysema".[31] The decrease in surface area per unit lung volume approximately is linear and continuous throughout life.[32]

Conclusion

The outcome of present study indicates that age negatively correlates with pulmonary functions. Age gap between subjects is related to highly significant reduction in PFT values. The results obtained have both clinical and public health significance for evaluating the changes due to aging.

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