ORIGINAL RESEARCH

Assessment of ventilatory test among healthy subjects of North India with no history of smoking – A computerized spirometry study

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ABSTRACT
Background: Spirometry is an excellent screening test for detection of chronic airflow obstruction, localizing and grading a critical orifice in the central airways, but may also be useful in detecting restrictive disorders. The present study was a computerized spirometry study conducted to assess ventilatory test among healthy subjects of North India with no history of smoking. **Material & methods:** The present study was conducted in the Department of Physiology, Government Medical College, Patiala, Punjab. A detailed physical examination and different lung function tests were carried out. Mean, standard deviation and standard error of mean and coefficient of variation was calculated and the same represented by tables**. Results:** Maximum mean and SD Peak Expiratory Flow rate in males was found in age group 50-59 years i.e. 6.95±1.20 Its/sec as compared to 60 and above age groups. Maximum mean MVV in males was found in age group 50-59 years i.e. 109.5±1.20 Its/secas compared to 60 and above age groups. Maximum mean MVV in females was found in age group 50-59 years i.e. 96lts/secas compared to 60 and above age groups. Mean FEF 25-75%,mean FEF 2-12%, FEF 25% , FEF 50%, FEF 75% was higher in males of age group 50-59 yearsas compared to 60 and above age groups. Mean FEF 25-75%, mean FEF 2-12%, FEF 25%, FEF 50%, FEF 75% was higher in females of age group 50-59 years as compared to 60 and above age groups. **Conclusion:** The study concluded that Maximum mean Peak Expiratory Flow rate, maximum mean MVV in males, Maximum mean MVV in females was found in age group 50-59 years as compared to 60 and above age groups. Mean FEF 25-75%, mean FEF 2-12%, FEF 25%, FEF 50%, FEF 75% was higher in both males and females of age group 50-59 years as compared to 60 and above age groups.
Keywords: FEF, Peak Expiratory Flow rate, MVV.

INTRODUCTION

Pulmonary function tests permit accurate, reproducible assessment of the functional state of the respiratory system. It is worth emphasizing that pulmonary function tests do not diagnose specific diseases. Different diseases cause different patterns of abnormalities in a battery of pulmonary function tests. These patterns allow us to quantify the severity of respiratory disease, which enables us to detect disease early and characterize the natural history and response to treatment.[1] Spirometry provides a simple noninvasive method for assessing pulmonary function, and is a key tool in the diagnosis of obstructive and restrictive lung diseases. Accurate interpretation of the results from spirometry testing requires knowledge of expected normal values in a healthy population. Since pulmonary function is influenced by physiological factors such as age, height, sex and weight, estimation of normal values is facilitated by reference equations that take into account an individual's relevant characteristics.[2] Normative ranges for lung function also show striking differences between populations; with higher lung function among people of European ancestry, compared to African-American and Asian populations.[2] Spirometer is one of the most important and commonly used instruments for screening, diagnosis and monitoring of respiratory diseases and is increasingly advocated in primary care practice. It is well-known that differences in pulmonary function in normal people may be due to ethnic origin, tobacco smoking, age, height, sex, and socioeconomic status.[3]It is well known that age, height and weight are the main factors which affect the Peak Expiratory Flow Rate (PEFR), the Forced Expiratory Volume in the first second (FEV_1) and the Forced Vital Capacity (FVC).[4] There is a good correlation between the PEFR and the FEV_1. The coefficient of correlation between the PEFR and the FEV_1 is 0.516. The PEFR can be easily measured by using a peak flow meter which is easily portable and cheap, whereas the FEV_1 can only be measured by using a spirometer.[5] The present study was a computerized spirometry study conducted to assess ventilatory test among healthy subjects of North India with no history of smoking.

MATERIAL AND METHODS

The present study was conducted in the Department of Physiology, Government Medical College, Patiala, Punjab. This study included 200 healthy populations between 50 years and above years of age who had responded favourably to our appeal for co-operation in carrying out this investigation. The subjects have been drawn from amongst healthy residents of Patiala. People belonging to all socio-economic strata of the community had been adequately represented. The subjects had been judged to be healthy on the following criteria.

- No history of smoking.
- No history, current or past, of any cardio respiratory disorder or frequent colds.
- No exertions dyspnoea or general debility.
- No obvious signs of malnutrition or skeletal deformity.
- No obesity.

A detailed physical examination was carried out to rule out any cardio-respiratory disorder. In all subjects haemoglobin estimation was done and persons with normal haemoglobin level were judged healthy. The decision whether or not to be included a given subject in the present investigation was taken before function testing. Once included, none was subsequently rejected except when he was unable to give the desired co-operation in the experimental procedures.
The terminology and abbreviations used for different lung function tests carried out were as suggested by Gandevia and Hughjones (1957)and Cotes (1965).

ABBREVIATIONS

1. Body Surface Area. B.S.A
2. Forced Vital Capacity. F.V.C
3. Forced expiratory volumes over fixed time intervals. F.E.V.t
   i. t = 0.5, 1.0 and 3 seconds
4. Peak Expiratory Flow rate P.E.F.R.
5. Maximum Mid Expiratory flow rate F.E. F. 25-75%
6. Mean Forced expiratory Flow rate between FEF2-12
7. 0.2-1.2 litres of volume change
8. (uncontrolled frequency)
9. Forced expiratory flow after 25% of the F.E.F.25%
10. F.V.C. has been expired.
11. Forced expiratory flow after 50% F.E.F.50%
12. of the FVC has been expired.
13. Forced expiratory flow after 75% of the F.E.F.75%
14. FVC has been expired.
15. Forced expiratory volume (timed) to forced F.E.V. 0.5/FVC%
16. vital capacity ratio expressed as percentage FEV 1.0/FVC% FEV3.0/FVC%
17. Maximum Voluntary Ventilation. M.V.V.

SPIROMETER

The ventilatory tests were measured with a computerized spirometer 'Medspiror'. It is designed to be used with electromechanical pneumotach. Built in printer permits print-outs containing all patient information and calculated values of all 14 parameters.
Volume detection was done by pneumotach sensor and flow detection by volume differential method. It's overall accuracy is within+ 1% and it's range for volume is 0 to 10 litres and for flow is 0 to 20 litrs/second.
Testing procedures were quite simple from the patient's point of view. Only two manoeuvres were required to accumulate all test data, a forced vital capacity and a maximum voluntary ventilation. All gas volumes werecorrected to B.T. P.S. (body temprature, ambient pressure and saturatedwith water vapour) automatically by the instrument.

TECHNIQUE

Tests were performed in the laboratory. Tests were carried out in standing posture. Before doing the tests body height was noted in standing upright position without shoes in centimetres. Body weight was measured in kilograms. Body surface area was calculated fromDubois and Dubois (1916).

A nose clip was attached to the patient and a clean mouth-piece wasinserted into the breathing tube. Two manoeuvres were required from the subject, a forced vital capacity and a maximum voluntary ventilation.

1. **Forced Vital Capacity test procedure:** Subject was explained to takemaximum inspiration and then place mouth-piece firmly in mouth and perform maximum expiration and then remove mouth-piece.
2. **Maximum Voluntary Ventilation test procedure:** After rest of 5 minutes subject was asked to breathe as rapidly and deeply as possible in and from the mouth-piece. M.V.V. test was run for 12 seconds.

Results were taken on the built in printer containing all the patient information and calculated values of all the 14 parameters. This printout was attached along with the proforma.

PRECAUTIONS TAKEN DURING THE MANOEUVRES WERE

1. It was made sure that the subject inspires maximally and put in hisbest efforts during expiration.
2. It was made sure that there was no air leakage around the mouth piece.

STATISTICAL ANALYSIS

Mean, standard deviation and standard error of mean and coefficient of variation was calculated and the same represented by tables**.**

RESULTS

Table 1: Mean, standard deviation, standard error of mean and coefficient of variation of mean and coefficient of variation of lung function parameters in different age groups of males.

Age Group (yrs)	PEFR (lts/sec) in males			
	Mean	SD	SEM	CV
50-59	6.95	1.20	0.20	17.3
60-69	5.70	0.52	0.08	9.1
70-79	5.07	0.43	0.09	8.4
80 & above	2.76	0.83	0.26	30.7

Maximum mean and SD Peak Expiratory Flow rate in males was found in age group 50-59 years i.e. 6.95±1.20 lts/sec, maximum standard error of mean was found in age group 80 &above years i.e, 0.26 and maximum coefficient of variation of mean was found in age group 80 & above years i.e, 30.7.

Table 2: Mean, Standard Deviation, Standard Error Of Mean And Coefficient Of Variation Of Mean And Coefficient Of Variation Of Lung Function Parameters In Different Age Groups Of Males.

Age Group (yrs)	MVV (lts/min) in males				MVV (lts/min) in females			
	X	SD	SEM	CV	X	SD	SEM	CV
50-59	109.5	6.45	1.09	5.88	96.0	15.2	1.88	16.3
60-69	100.2	5.50	0.93	5.48	82.9	18.1	2.13	21.9
70-79	79.3	7.09	1.58	8.93	66.6	14.1	2.23	21.1
80 & above	48.0	7.48	2.36	15.5	41.5	9.06	2.02	21.8

Maximum mean MVV in males was found in age group 50-59 years i.e. 109.5±1.20 lts/sec, maximum SD MVV in males was found in age group 80 & above years i.e. 7.48, maximum standard error of mean was found in age group 80 & above years i.e, 2.36 and maximum coefficient of variation of mean was found in age group 80 & above years i.e, 15.5.Maximum mean MVV in females was found in age group 50-59 years i.e. 96 lts/sec, maximum SD MVV in females was found in age group 60-69years i.e. 18.1, maximum standard error of mean was found in age group 70-79 years i.e, 2.23 and maximum coefficient of variation of mean was found in age group 60-69 years i.e, 21.9.

Table 3: Mean, standard deviation, standard error of mean and coefficient of variation of mean and coefficient of variation of lung function parameters in different age groups of males.

Age Group (yrs)	FEF 25-75% (lts/sec)				FEF 2-12% (lts/sec)				FEF 25% (lts/sec)				FEF 50% (lts/sec)				FEF 75% (lts/sec)			
	X	SD	SEM	CV	X	SD	SEM	CV	X	SD	SEM	CV	X	SD	SEM	CV	X	SD	SEM	CV
50-	2.	0.	0.1	23	5.	1.	0.2	23	5.	1.	0.1	19	3.	0.	0.1	24	1.	0.	0.0	27

59	73	64	1	.4	33	27	1	.8	83	11	8	.0	29	80	3	.3	26	35	6	.7
60-69	1.99	0.46	0.07	23.1	3.65	0.69	0.11	18.9	4.42	0.61	0.10	13.8	2.44	0.48	0.08	19.6	0.96	0.31	0.05	32.2
70-79	1.69	0.19	0.04	11.2	2.73	0.48	0.10	17.5	3.89	0.58	0.13	14.9	2.06	0.25	0.05	12.1	0.78	0.11	0.02	14.1
80 & above	1.40	0.29	0.09	20.7	1.39	0.36	0.11	25.8	2.42	0.78	0.24	32.2	1.74	0.41	0.13	23.5	0.71	0.19	0.06	26.7

Mean FEF 25-75%,mean FEF 2-12%, FEF 25% , FEF 50%, FEF 75% was higher in males of age group 50-59 years.

Table 4: Mean, Standard Deviation, Standard Error Of Mean And Coefficient Of Variation Of Mean And Coefficient Of Variation Of Lung Function Parameters In Different Age Groups Of Females

Age Group (yrs)	**FEF 25-75% (Its/sec)**				**FEF 2-12% (Its/sec)**				**FEF 25% (Its/sec)**				**FEF 50% (Its/sec)**				**FEF 75% (Its/sec)**			
	X	SD	SEM	CV	X	SD	SEM	CV	X	SD	SEM	CV	X	SD	SEM	CV	X	SD	SEM	CV
50-59	2.31	0.64	0.07	27.7	4.25	1.45	0.17	34.1	5.06	1.13	0.13	22.3	2.80	0.77	0.09	27.5	1.05	0.33	0.03	31.4
60-69	1.88	0.38	0.04	20.2	3.15	0.28	0.09	24.7	4.12	0.64	0.07	15.5	2.30	0.41	0.04	17.8	0.89	0.24	0.02	36.9
70-79	1.62	0.23	0.03	14.1	2.31	0.63	0.09	27.2	3.50	0.70	0.11	20.0	2.02	0.32	0.05	15.8	0.75	0.12	0.01	16.0
80 & above	1.38	0.24	0.05	17.3	1.33	0.29	0.06	21.8	2.27	0.72	0.16	31.7	1.66	0.41	0.09	24.6	0.71	0.07	0.01	9.85

Mean FEF 25-75%,mean FEF 2-12%, FEF 25% , FEF 50%, FEF 75% was higher in females of age group 50-59 years.

Table 5: 't' values of simple Correlation coefficient

Parameter	Age	PEFR	FEF 25-75%	FEF 2-12%	FEF 25%	FEF 50%	FEF 75%
Age							
PEFR	14.62						
FEF 25-75%	9.02	11.55					
FEF 2-12%	-13.82	19.64	31.22				
FEF 25%	13.82	21.88	20.22	31.22			
FEF 50%	9.32	10.07	38.89	32.70	18.76		
FEF 75%	7.76	8.18	23.72	18.22	12.19	17.70	

Table 6: 'p' values of simple Correlation coefficient

Parameter	Age	PEFR	FEF 25-75%	FEF 2-12%	FEF 25%	FEF 50%	FEF 75%
Age							
PEFR	<0.0001						
FEF 25-75%	<0.001	<0.0001					
FEF 2-12%	<0.0001	<0.0001	<0.001				
FEF 25%	<0.0001	<0.001	<0.001	<0.0001			
FEF 50%	<0.001	<0.001	<0.0001	<0.0001	<0.0001		
FEF 75%	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

DISCUSSION

In clinical practice the interpretation of a given lung funciton test value under pathological states depends upon its comparison with normal value in health of the same individual. The latter values are hardly ever available for any such subjects. From the practical stand point however the normal values are predicted through regression equations derived from studies on healthy population.

A multivariate regression analysis has been done to establish the regression equations based on the data of the large number of subjects collected on 200 healthy individual with age ranging from 50 years and above.

The present study was carried out over the computerized spirometer, "Medspiror. "

PEFR is the gas exhaled in $1/10^{th}$ of a second during forced expiratory manoeuvre when recoiling forces of the lungs and contractile forces of respiratory muscles are functioning maximally and supporting the expiration to the maximal.[6]

Peak flow has been defined by Wright and Mekerrow (1959)[7] as ahighest flow rate sustained by a subject for atleast 10 seconds when a person expires with increasing force, there comes a maximum despite an increase in the expiratory flow. This is because the pressure on the outside of the lungs by the chest wall compresses not only alveoli, but also respiratory passages. Therefore beyond a certain compressive force, the resistance to air flow in the passage increases as rapidly as the pressure in the alveoli which prevents the further increase in the flow. When the lungs were expanded, the respiratory passages were also expanded, the maximum expiratory flow rate was great. However, as lung approaches zero, the airway resistance goes to infinity which reduces the flow rate to zero. Therefore a person can breathe out much more rapidly at the beginning than at the end of expiration. For males it is about 537 litres per minute and for female it was little less.

In the present study it is seen that there is a significant decrease in male subjects as well as in female subjects. It also shows significantdecrease in the total study group i.e. it is negatively correlated with age.

The regression equation observed in the present study in malegroup to predict PEFR has partial regression coefficient for age (-0.0117). The regression equation in present study for females to predict PER has partial regression coefficient for age (0.094). Partial regression coefficient for total study to predict PEFR has partial regression coefficient for BSA (6.38).

Meenakshi, S, (1984) found that expiratory flow decreased with advancement of age and decrease in FVC, FEV1 and expiatory flow were more definite in old age.[8]

Our findings are similar to the findings of Chatterjee, S. et al.(1988)[9], M.B. Dikshit, et al. (1991)[10].

The $FEF_{25\%–75\%}$, or *forced expiratory flow between 25% and 75% of FVC,* was introduced as the maximal midexpiratory flow rate. This measurement was intended to reflect the most effort-independent portion of the curve and the portion most sensitive to airflow in peripheral airways, where diseases of chronic airflow obstruction are thought to originate.[11] These characteristics have gained momentum from clinical experience and theoretical analysis, and the $FEF_{25\%–75\%}$ is widely used currently.[12] However, the $FEF_{25\%–75\%}$ shows marked variability in studies of large samples of healthy subjects, and the 95% confidence limits for normal values are so large that they limit its sensitivity in detecting disease in an individual subject.[13]

In the present study FEF25-75% show a significant decrease inall the three study groups with advancing age. It shows a negative and highly significant correlation with age.The regression equation observed in the present study in males to predict FEF 25-75% had partial regression coeficient forage0.001). The regression equation in present study for females to predict FEF 25-75% had partial regression cocfficient for age (-0.0256). for height (0.033) for weight (0.033).

Partial regression coefficient for total study to predict FEF 25-75% has partial regression coefficient for age (-0.0264), for weight (-0.001) and for height (0.044).

Our findings tally with a findings of Chatterjee, S. et al.(1988)[9], Wu, H.D. et al. (1990)[14], Yang, S.C. (1993)[15].

FEF2-12% (Mean forced expiratory flow rate between 0.2-1.2 litres ofvolume change)

In present study FEF2-12 shows highly significant decrease in male study group and female study as well as the total study group. It shows a negative correlation with age. Our study is concurrent with the study of Chatterjee, S. et al. (1988)[9], Yang, S.C. (1993)[15].

In the present study it is seen that there is a decrease in FEF 25%in all the three study groups with advancing age i.e. it has a negative correlation with age. FEF25% in case of males regress best with age and BSA in females with age and height and in total study group it regresses best with age and height. A study go with the studies of Wu, H.D et al. (1990)[14],Yang, S.C. (1993)[15].

In the present study we see that FEF 50% decreases with increasing age in both the sexes i.e. the negative correlation with age. In case of males, females and total study group FEF 50% regress with age and height.

Our study tally with the study of Wu, H.D. et al. (1990)[14], Yang, S.C.(1993)[15].

In the present study we see that FEF 75% decreases with increasing age in both the sexes i.e. the negative correlation with age. In case of males, females and total study group FEF 75% regress with age, height and weight. Our study tally with the study of Wu, H.D. et al. (1990)[14], Yang, S.C.(1993)[15].

MVV (maximum ventilatory volume)represents the greatest volume of air that can be ventilated on command during a given interval. Normal subject can attain maximum value of 100 litres or more in a minute. Males in the age group 16 to 34 yearsshow a range of 82 to 169 litre per minutes older subjects are not capableof such high ventilation volumes.

In the present study we see that MVV decreases significantlywith increasing age in both the sexes i.e. the negative correlation with age.

The regression equation observed in the present study in male group to predict MVV has partial regression coefficient for age (-1.797). The regression equation in present study for females to predict MVV has partial regression coefficient for age (-1.441), partial regression coefficient for total study to predict MVV has parallel regression coefficient for age (-1.442). Our study tally with the study of Chatterjee, S. et al. (1988)[9].

Mittal S et al conducted a study to measure PEF in healthy Punjabi children aged 7-14 years as only a few studies have evaluated the lung functions in North Indian children. The present study showed that all the three independent variables (age, height, and weight) had a significant positive correlation with PEF, in both genders. Furthermore, height was maximally correlated with PEF in both boys (r = 0.970) and girls (r = 0.964). The mean PEF value in boys (249.34 ± 81.36 L/min) was significantly higher than girls (233.31 ± 67.06 L/min).[16]

Singh I et al studied the spirometric parameters in normal healthy Punjabi males of rural and urban areas between 20 and 50 years of age group. The ventilatory tests such as peak expiratory flow rate (PEFR), forced expiratory flow (FEF)0.2%–1.2% and FEF25% measured by computerized spirometer (Med-spiror) showed a highly significant decline in urban subjects. While in rest of the parameters, there is statistically non significant decrease in urban subjects. The cause of decline in flow volume in urban subjects is owing to industrial pollution (SO2 , SO4 2-, NO2), suspended particulate matter and cumulative dust exposure, and exhaust emission of vehicles. The cause of better preserved lung function, especially the flow volumes in rural subjects is owing to excessive physical activity and because of nonexposure to pollution.[17]

CONCLUSION

The study concluded that Maximum mean Peak Expiratory Flow rate, maximum mean MVV in males, Maximum mean MVV in females was found in age group 50-59 years as compared to 60 and above age groups. Mean FEF 25-75%,mean FEF 2-12%, FEF 25%, FEF 50%, FEF 75% was higher in both males and females of age group 50-59 years as compared to 60 and above age groups.

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