Original Article

Normative Spirometric Values in Adult Kashmiri Population

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ABSTRACT

Background. Normative values of pulmonary functions of healthy population are affected by different geographic, ethnic, climatic and demographic factors.

Objective. Present study was designed to derive normative spirometric values, prediction equations for future reference in adult Kashmiri population.

Methods. Pulmonary function testing was carried out on 3080 normal healthy non-smoking individuals (1974 males; age 18-65 years) of Kashmir valley. Multiple regression analysis was used to develop prediction equations for use in this population.

Results. Forced vital capacity (FVC, L/s) (4.3±0.8 *versus* 3.0±0.5; p<0.05), forced expiratory volume in the first second (FEV_1, L/s) (3.9±0.7 *versus* 2.6±0.5; p<0.05) and peak expiratory flow rate (PEFR, L/s) (7.9±1.8 *versus* 5.3±1.2; p<0.05) were significantly higher in males in comparison with females. All the other parameters except FEV_1/PEFR ratio were significantly higher among males (p<0.05). Irrespective of gender, all the parameters declined with increasing age. Females had higher FEV_1/PEFR ratio (p<0.05) in age group of 15-30 years. Overall the inter-group difference across the districts studied was not significant. Spirometric parameters manifested an overall negative correlation with increasing body mass index (BMI), although FVC and FEV_1 in males with low BMI were high (p<0.05).

Conclusion. These prediction equations can be utilised as reference values for future use in adult Kashmiri population.
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Key words: Pulmonary functions, Spirometric values, Body mass index, Kashmiri population.

INTRODUCTION

The differences observed in various lung function tests depend on age, sex, height, physical activity, smoking, besides socio-economic status, environmental conditions, altitude and ethnicity.[1,2] Spirometry has an established role in understanding various normal and pathological functions of respiratory system and thereby plays an important role in screening, diagnosing and monitoring respiratory functions in different conditions and disease states affecting lungs.[3,4] Further, spirometry is a helpful tool for evaluation of breathing reserve and exercise tolerance to determine physical fitness in normal people.[5]

Pulmonary function tests (PFTs) can identify respiratory abnormalities such as chronic obstructive pulmonary diseases that might otherwise be overlooked. Physicians cannot identify obstructive or restrictive patterns of respiratory diseases reliably from history and physical examination alone.[6-8] Only 83% and 50% of predictions in case of obstructive pattern and restrictive patterns, respectively were correct.[9] Lung function tests in addition can quantify severity and presence of reversible component of airflow obstruction. Further such testing is essential in the diagnosis and the management of bronchial asthma.[6] PFTs are also used when more than one explanation is there for patient's symptoms, evaluation of fitness, etc.

There is little evidence to support a policy of screening the general population with spirometry.[10] Screening and monitoring are appropriate for cigarette smokers and people exposed to agents known to cause lung injury, such as, asbestos who are at risk of developing lung disease.[10,11] In Framingham study,[12] decrease in vital capacity was a better predictor of heart failure and recovery than symptoms and signs.

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Although role of pre-operative PFTs remains controversial, goals are now clearly defined.[13-16] Low levels of lung functions are associated with poor prognosis in heart and lung diseases even in patients who have never smoked.[17,18]

Quality remains most important concern in lung function testing in view of greater variability than most other laboratory tests. The American Thoracic Society (ATS), European Respiratory Society (ERS) and others have published standard designs to minimise the variability in these tests.[19-21] High quality test results can be achieved by accurate equipment, good test procedures, ongoing quality control, appropriate reference values and good algorithm for the interpretation of results by comparing with values from healthy population.

This study was conducted in ethnic Kashmiri population for the first time with an aim to study the pulmonary function status of normal population and to generate prediction equations from this data for clinical use.

MATERIAL AND METHODS

This hospital-based study was conducted in Sher-i-Kashmir Institute of Medical Sciences, the only tertiary care deemed university hospital catering whole Kashmir valley. Healthy adult volunteers of both the genders who were the attendants, other relatives and friends of patients admitted in wards and in out-patient departments and medical staff fulfilling the preset criteria were studied. The study was conducted across all seasons and weather conditions to generate the normal PFT data for adult Kashmiri population for future reference in clinical practice.

The participation of subjects was purely on voluntary basis. After obtaining informed consent, non-smokers in the age range of 18 to 65 years were included as subjects. Data were recorded on a structured clinical record form. The sample size for the study was calculated as follows: The Census of India 2001 reported population of 5,441,341 for Kashmir valley spread over six districts.[22] The population proportion adjusted for 29 per thousand births and 8 per thousand deaths annually for the year 2006 was calculated to be 5,985,475 for the entire valley spread district-wise as: 1,287,014 for Anantnag; 713,638 for Pulwama; 1,301,842 for Srinagar; 695,621 for Budgam; 1,283,394 for Baramulla and 704,014 for Kupwara.

Target adult population for the study in the age group 18-65 years calculated as 55% of estimated population was computed to be 3,080,000. Taking one per thousand population as representative sample unit, the rationalised population to be included in the study contained 3080 individuals. District-wise distribution of target population worked out to be 650 for Anantnag; 350 for Pulwama; 650 for Srinagar; 350 for Budgam; 650 for Baramulla and 350 for Kupwara.

Based on this population proportion sampling of six districts, the study population was subjected to simple randomisation method and accordingly allocated to six clusters distributed across the mono ethnic population of Kashmir valley. Each cluster was having separate clinical record form group file having pre-calculated number of clinical record forms. The data of each individual was recorded in the form in its allocated group file.

The following subjects were excluded from the study: (i) patients with a history of chest trauma; tobacco smoking; exposure to substances known to cause lung injury i.e., asbestos, silica, cotton dust, coal, etc.; (ii) professions, such as, stone crushers, wood workers, cotton dust workers, pigeon breeders etc.; (iii) patients known to have other diseases such as bronchial asthma, pulmonary tuberculosis, pneumonia, chronic bronchitis, emphysema, hypertension,[23] diabetes mellitus or any abnormality detected on the physical examination of the heart, lungs and chest wall, ankle oedema; (iv) patients with an abnormal chest radiograph and electrocardiogram (ECG); and (v) patients using diuretics, cardiac glycosides or beta-adrenergic blocking drugs.

Each participant was screened by general physical and systemic examinations. The participants who qualified were taken for spirometry. In all subjects, spirometry was done from 9AM to 11AM under the ambient temperature and humidity across all the 12 months, irrespective of extreme weather conditions in the Pulmonary Physiology Laboratory of Clinical Pharmacology Department to avoid biovariability due to diurnal rhythm. Spirlab11 equipment (Medical International Research; Roma, Italy) was used for conducting the study. Calibration of machine before testing session was done on monthly basis for ensuring better quality although recommendations as per product user manual mandated calibration once in six months.

Best of three successive test readings was taken as final result and the primary values, i.e. forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), peak expiratory flow rate (PEFR), maximal mid-expiratory flow rate (FEF_{25-75}), peak inspiratory flow rate (PIFR) and the FEV_1/FVC and $FEV_1/PEFR$ ratios were recorded. Anthropometry was done by measuring weight in kilogram (Kg) with indoor clothing without shoes on a weighing machine; standing height was measured without shoes by a Harpenden's stadiometer (Cranlea and Company; Birmingham, UK); and body mass index (BMI) was calculated according to formula Kg/m^2. Patients were divided into three groups based on BMI as: low ($BMI<18.5Kg/m^2$), normal (BMI 18.5-24.9 Kg/m^2) and high ($BMI\geq25.0\ Kg/m^2$). These groups were then compared for various spirometric parameters amongst each other.

Statistical Analysis

Data were described as mean±standard deviation. Intergroup comparisons were made by utilising one-way analysis of variance (ANOVA) when three or more variables were compared. Student's t-test and Chi-square test were used for analysing within groups. Statistical Package for the Social Sciences (SPSS; version 11.5) software was used for the purpose. Best fitting cross-sectional equations were derived separately for males and females of different ages using multiple linear regression analysis based on age and height.

RESULTS

Overall, 3080 subjects were studied. There were 1974 (64%) males. Of these, 636 (20.6%) were from district Anantnag, 364 (11.8%) from Budgam, 696 (22.6%) from Baramulla, 353 (11.5%) from Kupwara, 359 (11.7%) from Pulwama and 672 (21.8%) from Srinagar (Figure).

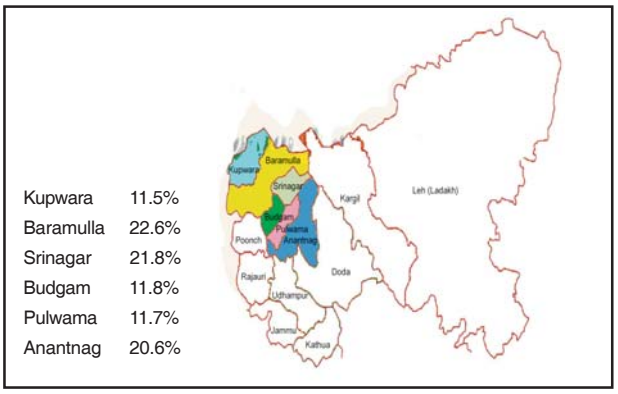

Figure. District-wise distribution of the studied subjects.

The age of subjects ranged between 18-65 years. The mean age of males and females was 37.5±11.8 years and 37.2±12.7 years, respectively. Various anthropometric parameters like, age, weight, height, BMI and body surface area are shown in table 1.

Table 1. Anthropometric characteristics

Characteristic	Gender	Min.	Max.	Mean±SD
Age (years)	Male	18	66	37.5±11.8
	Female	18	65	37.2±12.7
Weight (Kg)	Male	41	90	62.3±6.4
	Female	42	90	57.8±5.6
Height (cm)	Male	145	190	169.0±5.7
	Female	140	176	160.5±6.0
Body mass index (Kg/m^2)	Male	15.94	31.14	21.80±2.08
	Female	17.15	34.29	22.46±2.36
Body surface area (m^2)	Male	1.31	2.04	1.68±0.10
	Female	1.33	2.04	1.61±0.09

SD=Standard deviation

Lung volumes (FVC, FEV_1, PEFR, FEF_{25-75}, PIFR and FEV_1/FVC ratio) were higher in males across all age groups. However, these variables significantly ($p<0.05$) decreased with the advancing age in both the genders. The FEV_1/PEFR ratio was higher in females than males ($p<0.05$), especially in the age group of 15-30 years (Table 2). While comparing various spirometric parameters across various districts, Pulwama dwellers had a significantly lower FVC (L) compared with overall results for this parameter (males: 4.12±0.89 *versus* 4.29±0.77, $p<0.05$; females: 2.82±0.75 *versus* 3.00±0.51, $p<0.05$). Pulwama dwellers also had a significantly lower FEV_1 (L) (males: 3.70±0.78 *versus* 3.85±0.72, $p<0.05$; females: 2.44±0.64 against 2.64±0.48, $p<0.05$).

Table 2. Comparison of spirometric parameters as per age and gender

Variable	Age (years)	Male		Female	
		No.	Mean±SD	No.	Mean±SD
FVC (L)	15-30	670	4.5±0.7	426	3.2±0.5
	31-50	1052	4.4±0.7	492	3.0±0.5
	>50	252	3.4±0.6	188	2.6±0.5
	Total	**1974**	**4.3±0.8**	**1106**	**3.0±0.5**
FEV_1 (L)	15-30	670	4.0± 0.7	426	2.8±0.5
	31-50	1052	3.9±0.6	492	2.6±0.4
	>50	252	3.0±0.6	188	2.3±0.4
	Total	**1974**	**3.9±0.7**	**1106**	**2.6±0.5**
PEF (L/s)	15-30	670	8.2±1.8	426	5.4±1.3
	31-50	1052	8.0±1.7	492	5.4±1.1
	>50	252	6.4±1.5	188	4.9±0.8
	Total	**1974**	**7.9±1.8**	**1106**	**5.3±1.2**
FEF_{25-75} (L/s)	15-30	669	4.4±1.1	426	3.5±0.7
	31-50	1052	4.0±0.9	492	3.2±0.7
	>50	252	3.2±1.0	188	2.7±0.7
	Total	**1973**	**4.0±1.0**	**1106**	**3.2±0.8**
PIFR (L/s)	15-30	660	4.5±1.1	412	3.2±0.6
	31-50	1029	4.2±0.9	491	3.1±0.5
	>50	245	3.6±2.7	188	2.8±0.7
	Total	**1934**	**4.2±1.3**	**1091**	**3.1±0.6**
FEV_1/FVC	15-30	670	90.5±3.0	426	87.8±3.2
	31-50	1052	89.8±2.7	492	87.8±3.1
	>50	252	88.0±3.5	188	86.5±3.4
	Total	**1974**	**89.8±3.0**	**1106**	**87.6±3.2**
FEV_1/PEFR	15-30	670	51.1±12.0	426	54.8±14.9
	31-50	1052	50.7±11.9	492	50.4±13.6
	>50	252	49.0±14.1	188	47.5±10.9
	Total	**1974**	**50.6±12.2**	**1106**	**51.6±14.0**

All the spirometric characteristics across age among men did differ significantly except FEV_1/PEF. Moreover, the difference in characteristics across age in females was all through significant ($p<0.05$)

SD=Standard deviation; FVC=Forced vital capacity; FEV_1=Forced expiratory volume in the first second; PEF=Peak expiratory flow; FEF_{25-75}= Expiratory flow from 25% - 75% of FVC; PIFR=Peak inspiratory flow rate; PEFR=Peak expiratory flow rate

However, the other spirometric parameters were bearing insignificant changes. Prediction equations derived separately for males and females of different age groups using multiple linear regression analysis based on age and height are shown in tables 3 and 4.

Table 3. Derived equations for various spirometric parameters for male subjects

Variable	Age (years)	Male	R^2	SEE
FVC (L)	15 to 30	-0.416-0.021Age+0.032Height	0.080	0.685
	31 to 50	0.411-0.005Age+0.025Height	0.043	0.671
	≥50	-1.747-0.031Age+0.04Height	0.132	0.589
FEV_1 (L)	15 to 30	-1.136-0.014Age+0.033Height	0.091	0.627
	31 to 50	0.242-0.005Age+0.023Height	0.041	0.634
	≥50	-1.483-0.030Age+0.037Height	0.129	0.563
PEFR (L/s)	15 to 30	-0.517-0.007Age+0.053Height	0.031	1.744
	31 to 50	3.039-0.009Age+0.032Height	0.012	1.695
	≥50	-1.122-0.041Age+0.060Height	0.047	1.450
FEF_{25-75} (L/s)	15 to 30	-2.041+0.003Age+0.038Height	0.042	1.076
	31 to 50	0.631+0.002Age+0.019Height	0.015	0.862
	≥50	3.109-0.041Age+0.015Height	0.036	0.969
PIFR (L/sec)	15 to 30	1.077+0.000Age+0.020Height	0.012	1.082
	31 to 50	-1.833+0.000Age+0.036Height	0.049	0.872
	≥50	6.199-0.082Age+0.013Height	0.018	2.643
FEV_1/FVC (%)	15 to 30	72.742+0.106Age+0.089Height	0.052	2.891
	31 to 50	85.516-0.004Age+0.026Height	0.003	2.722
	≥50	84.987-0.085Age+0.047Height	0.014	3.537
FEV_1/PEFR (%)	15 to 30	38.889-0.074Age+0.083Height	0.002	12.029
	31 to 50	33.931-0.048Age+0.111Height	0.003	11.847
	≥50	31.544-0.094Age+0.137Height	0.003	14.061

FVC=Forced vital capacity; FEV_1=Forced expiratory volume in the first second; PEFR=Peak expiratory flow rate; FEF_{25-75}=Expiratory flow from 25%-75% of FVC; PIFR=Peak inspiratory flow rate; R^2=Coefficient of determination; SEE=Standard error of the estimate

Table 4. Derived equations for various spirometric parameters for female subjects

Variable	Age (years)	Female	R^2	SEE
FVC (L)	15 to 30	0.244-0.022Age+0.022Height	0.120	0.454
	31 to 50	0.508-0.004Age+0.016Height	0.044	0.446
	≥50	-0.772-0.002Age+0.022Height	0.074	0.442
FEV_1 (L)	15 to 30	-0.468-0.015Age+0.023Height	0.117	0.442
	31 to 50	0.063-0.004Age+0.017Height	0.053	0.416
	≥50	-1.356-0.002Age+0.024Height	0.095	0.410
PEFR (L/s)	15 to 30	-3.663-0.00Age+0.058Height	0.081	1.282
	31 to 50	-1.368-0.003Age+0.043Height	0.050	1.057
	≥50	-1.331+0.007Age+0.036Height	0.064	0.785
FEF_{25-75} (L/s)	15 to 30	-1.130-0.012Age+0.031Height	0.083	0.687
	31 to 50	2.004-0.003Age+0.008Height	0.005	0.714
	≥50	5.376+0.011Age-0.021Height	0.032	0.692
PIFR (L/sec)	15 to 30	0.211+0.009Age+0.017Height	0.032	0.620
	31 to 50	2.071-0.002Age+0.007Height	0.006	0.547
	≥50	-2.900+0.008Age+0.033Height	0.078	0.646
FEV_1/FVC (%)	15 to 3	67.8+0.137Age+0.105Height	0.070	3.139
	31 to 50	75.836-0.012Age+0.077Height	0.020	3.095
	≥50	54.976-0.021Age+0.205Height	0.118	3.166
FEV_1/PEFR (%)	15 to 30	120.327-0.180Age-0.381Height	0.030	14.757
	31 to 50	79.384-0.027Age-0.174Height	0.005	13.058
	≥50	36.502-0.117Age+0.111Height	0.005	10.929

FVC=Forced vital capacity; FEV_1=Forced expiratory volume in the first second; PEFR=Peak expiratory flow rate; FEF_{25-75}=Expiratory flow from 25%-75% of FVC; PIFR=Peak inspiratory flow rate; R^2=Coefficient of determination; SEE=Standard error of the estimate

While comparing spirometric parameters with different BMI groups, FVC, FEV_1, FEV_1/FVC, FEF_{25-75} values in males overall were low in low BMI (<18.5 Kg/m^2) group as compared to patients with a normal BMI (18.5-24.9 Kg/m^2). The afore-mentioned spirometric values showed a decreasing trend as BMI increased from normal to (≥25.0) than the normal values. However, spirometric values showed significance only between low/normal BMI group for FVC and FEV_1/FVC and across all groups for FEV_1 and $FEF_{25\%-75\%}$ only. Similar observations for these parameters was evident among women also. However, significance in values in females were seen between lo/high and normal/high BMI group for FVC only. PEFR values showed same pattern ($p<0.5$) in normal/high BMI groups among the females only. PIF, FEV_1/PEF values were not effected by BMI in both the genders (Table 5).

Table 5. Spirometric measurements in relation to body mass index

Variable	Body Mass Index	Male (Mean±SD)	Female (Mean±SD)
FVC (L)	Low (<18.5)	4.10±0.80*	3.11±0.62
	Normal (18.5 to 24.9)	4.29±0.76	3.03±0.51†
	High (≥25.0)	4.27±0.85	2.83±0.46‡
	Total	**4.29±0.77**	**3.00±0.51$**
FEV_1 (L)	Low (<18.5)	3.65±0.74	2.74±0.61
	Normal (18.5 to 24.9)	3.87±0.71	2.66±0.48†
	High (≥25.0)	3.82±0.81	2.48±0.44‡
	Total	**3.85 ±0.72$**	**2.64±0.48$**
FEV_1/FVC (%)	Low (<18.5)	88.97±3.66*	87.47±3.53
	Normal (18.5 to 24.9)	89.89±2.97	87.62±3.27
	High (≥25.0)	89.36±3.16	87.38±3.04
	Total	**89.82 ±3.01$**	**87.59±3.25**
PEFR (L/s)	Low (<18.5)	7.77±1.81	5.72±1.28
	Normal (18.5 to 24.9)	7.90±1.77	5.34±1.16†
	High (≥25.0)	7.95±2.14	5.16±1.15
	Total	**7.89±1.79**	**5.32±1.16**
FEV_1/PEFR (%)	Low (<18.5)	49.48±15.22	48.53±9.71
	Normal (18.5 to 24.9)	50.69±12.14	51.87±14.09
	High (≥25.0)	50.09±11.57	50.24±13.79
	Total	**50.60±12.24**	**51.57±13.97**
FEF_{25-75} (L/s)	Low (<18.5)	4.31±1.43 *	3.62±0.85*
	Normal (18.5 to 24.9)	4.03±1.01†	3.25±0.75†
	High (≥25.0)	3.83±1.03‡	3.03±0.79‡
	Total	**4.03±1.03$**	**3.23±0.77$**
PIFR (L/s)	Low (<18.5)	4.04±0.89*	2.97±0.64
	Normal (18.5 to 24.9)	4.24±1.00†	3.11±0.62
	High (≥25.0)	4.45±3.74	3.08±0.59
	Total	**4.24±1.34**	**3.10±0.61**

BMI: Low: ≤18.5; Normal: 18.5 to 24.9; High: ≥25

*, †, ‡, $ represent difference between low/normal, normal/high, low/high and overall (ANOVA) comparison among the three BMI groups respectively.

SD=Standard deviation; FVC=Forced vital capacity; FEV_1=Forced expiratory volume in the first second; PEFR=Peak expiratory flow rate; FEF_{25-75}= Expiratory flow from 25% - 75% of FVC; PIFR=Peak inspiratory flow rate

Comparison of FVC, FEV_1 observed in the present study with the corresponding predicted values published from various regions of India and observations reported in Caucasians is shown in tables 6 and 7.

Table 6. Predicted spirometric values from various studies in males of age group (31-50 years)

Study	FVC (L)	FEV_1 (L)
Indian Studies		
Jain (North India)[34]	3.95	
Udwadia (West India)[35]	3.54	2.8
Kamat (South India)[36]	3.34	2.84
Vijayan (South India)[33]	3.37	2.92
Saleem (Present study)	4.42	4.00
Caucasian Studies		
Cotes[38]	4.44	3.67
Goldman[37]	4.29	

FVC=Forced vital capacity; FEV_1=Forced expiratory volume in the first second

Table 7. Predicted spirometric values from various studies in females of age group (31-50 years)

Study	FVC (L)	FEV_1 (L)
Indian Studies		
Jain (North India)[39]	2.78	
Udwadia (West India)[35]	2.61	2.02
Kamat (South India)[36]	2.34	1.89
Vijayan (South India)[33]	2.54	2.13
Saleem (Present study)	3.12	2.76
Caucasian Studies		
Goldman[37]	3.16	
Hall[40]	3.48	2.81

FVC=Forced vital capacity; FEV_1=Forced expiratory volume in the first second

DISCUSSION

Lung function is known to vary with ethnicity.[24,25] It has been observed that FVC and FEV_1 are significantly lower in Asian-Americans than European-Americans for the same height representing a true physiological difference in the two ethnic groups.[24] Similarly spirometric parameters were 5% to 19% higher in white population than for Hong Kong-Chinese.[25] Aggarwal *et al*,[26] in a comparative study of Indian reference equations between North, South and West found that these equations do not yield equivalent results and can lead to erroneously under- or over-interpretation. Therefore, it is important to derive normative lung function values for a particular population before these can be used for any diagnostic or prognostic purposes in a community.

Establishing regression equations to predict various measurements of normal lung functions on a regional basis in our country with diverse conditions is important. Results for comprehensive lung functions are available from various regions; however, there is no study available for comparison from our ethnic population. In the present study, linear regression models were derived from spirometric data from this population and derived values from these equations were compared with other studies from India and Caucasians. The spirometric values as seen in our study are consistent with previous studies[27-30] and were variable with age, sex and height. The lung function values showed decline with increase in age, a pattern similar to all national[27] and international studies.[28,30,31] These values were independent of other variables like gender and built.

Mean PFT values were higher in males than females in both younger and old age groups. Golshan *et al*[30] in a large Middle-East population study observed that parameters tend to increase with age before 20 years while after 20 years these show a decline. In healthy Pakistani adults it was observed that the height and age were always found to be important predictors of lung function parameters.[31]

Although confounding of different factors of bio-variability influence pulmonary functions and resultant functional status is an outcome of the simultaneous influence of age, gender, body height, weight, ethnicity, environmental factors including altitude. The white populations had higher spirometric values than in our population.[32] This cannot be explained on the basis of factor analysis as the variables were not clearly defined but the ethnic factor was a paramount difference between the two studies. However, in this study,[32] male white population had higher values than females similar to observation in the present study. This could be due to higher mean height, the difference in hormone profile, stronger respiratory muscles, greater activity and bigger size of lungs and airways. Airways of women have 17% smaller diameters than the airways of mature men.[33] Boys tend to have larger lungs per unit of stature than girls even though number of alveoli per unit volume and area was identical, total number of alveoli were more in boys than girls resulting in higher lung function.[33] Since the height bears positive correlation with spirometric parameters, the difference may be explained on the basis of body height as one of the contributing factors.[29,31,33]

While comparing our data with reference values from North, West and South regions of India, our population had higher values which could be due to different ethnicity, greater mean height and high altitude.[33-36,39] Whereas FVC and FEV_1 values in our study were similar to that of Caucasians in both the genders.[29,37,38,40]

It was also observed that people at higher altitudes like our population have significantly higher spirometric values than low-landers and Caucasians because of ethnicity, inherited adaptive response in highlanders and possibly genetic influence too.[41,42] Chhabra *et al*[43] also observed that vital capacity and other spirometric parameters were higher in adult males in North and East than South and West in India because of regional variations probably due to ethnicity and altitude.

In an another study,[44] in healthy volunteers (n=21) maximal expiratory flow rate at 50% of FVC ($MEFR_{50}$) and maximal expiratory flow rate at 75% of FVC ($MEFR_{75}$) have a positive correlation with altitude. Inter district comparison was similar except in Pulwama district which could be due to genetic influence, because their various other parameters including altitude were not different from other districts.

The impact of the built and the overall body mass on pulmonary function have been evaluated and correlated by researchers reporting that there is negative correlation between PFTs and the physical profile of an individual expressed in terms of BMI and weight gain is associated with more rapid loss of lung function.[44] Pulmonary functions were higher in subjects with lower BMI in both males and females though not in all parameters in our study. This pattern is similar to the observations reported by Ochs-Balcom *et al*.[45] The likely reason could be that BMI is determinant of adiposity, which is inversely related with pulmonary function parameters. Thyagarajan *et al*[46] found that in healthy young adults, increasing BMI in the initially thin participants was associated with increasing then stable lung function through age 38 years, but there were substantial lung function losses with higher and increasing fatness, suggesting that the obesity epidemic threatens the lung health of the general population.

In view of different ethnic background and different lung function parameters as compared to North, West, and South regions and from Caucasians, it highlights the importance of having separate normal prediction equations of lung functions based on normative spirometric values in adult Kashmiri population for use in health and disease. Local reference values are more biologically and technically suitable for the interpretation of spirometric data.

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