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Age Related Changes in Lung Function Traits of Santal Stone Mine Workers of Birbhum District, West Bengal

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ABSTRACT
Lung function measurement is one of the ways of assessing respiratory health status. Stone mine workers are prone to lung problems due to stone dust, are a great concern from public health point of view. The aim of the study was to understand the nature of age related changes in lung function traits of the Santal stone mine workers of Birbhum district, West Bengal. Cross-sectional data on lung function traits including FVC, $FEV_{1.0}$, $FEV_{1.0}$/FVC and PEFR have been collected from 328 (149 males, 179 females) healthy adult Santal stone mine workers of Birbhum district, West Bengal. Statistical analysis including descriptive statistics, ANOVA and linear regression analysis were done separately for males and females for each lung function trait. The value of FVC and $FEV_{1.0}$ reaches its peak within 25 years of age and then gradually decreases in both sexes. Similarly, the $FEV_{1.0}$/ FVC ratio decrease with the increment of age in both sexes. The peak value of PEFR reaches between 25-34 years of age in male, but in case of female the peak value of PEFR reaches between 35-44 years of age. The ANOVA result showed that significant differences ($P \leq 0.05$) exists between/among age cohorts in terms of mean values of all the lung function traits for both males and females. The result of linear regression equation for lung function traits on age were as follows: $FVC_{male}=3.168–0.015\times age$, $FVC_{female}=2.214–0.012\times age$, $FEV_{1.0male}=3.119–0.021\times age$, $FEV_{1.0female}=2.111–0.013\times age$, $FEV_{1.0}/FVC_{male}=1.004–0.003\times age$, $FEV_{1.0}/FVC_{female}=0.953+0.0006\times age$, $PEFR_{male}=8.649–0.064\times age$, $PEFR_{female}=4.690–0.014\times age$. Therefore, it seems that lung function traits gradually decline with progression of age and the pattern is similar in both sexes. However, generalization cannot be made out of this small-scale study.
Keywords: Lung function, age groups, Santal

INTRODUCTION

Respiratory disease including asthma and chronic obstructive lung diseases (COPD) are the second largest disease throughout the globe. WHO (2008) estimated that annually 2.5 million deaths occur globally due to chronic respiratory disease. However, the prevalence rate varies across countries, across regions and so on. In India, around 100 million individuals are

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suffering from chronic respiratory disease which may attributable to higher exposure to environmental pollution (both indoor and outdoor) (including particulate matter, tobacco smoking and smoke generated from solid fuel as well fossil fuel) (ICMR, 2010). Therefore, assessment of respiratory health has both clinical and epidemiological importance (Barreiro and Perillo, 2004). Several studies have shown that lung function test is the one of the ways to assess the respiratory health status (Miller et al., 2005; Pellegrino et al., 2005; Young et al., 2007) and risk of cardio-vascular morbidity (Sparrow et al., 1988; Leone et al., 2009).

Studies reported that lung function traits have a linear relationship with stature, body weight and other anthropometric indices (Bottai et al., 2002; Roy et al., 2015). On the other, altitude (Frisancho, 1975), sex and ethnic group (Yang et al., 1991; Korotzer et al., 2000) plays an important role in determining the size and capacity of lungs. Empirical studies have shown that up to adolescent period, the lung function is generally independent of age, reaches its maximum volume around 25 years of age and thereafter it deteriorates with age in a linear fashion (Cotes, 1979; Kerstjens et al., 1997). However, the exact causes of age related changes in lung function traits are poorly documented because of several confounding factors. But, theoretically, the respiratory system undergoes various structural, physiological and immunological changes with the increase of age, which may be the resultant factor for the deterioration of lung function traits (Cotes, 1979; Chatterjee, 1987). Wabha (1983) pointed that decrease in motor power, loss of respiratory muscle strength, increase in the stiffness of thoracic cage and decrease in the size of inter vertebral space are basic changes that affect lung functions as with aging process. The elastic fibres around alveolar duct starts losing its elasticity with aging process, causing less expansion of the lung (reduces air space) (Janssens et al., 1999). Therefore, age has obviously an effect on the lung function traits of individual.

Cohn and Donoso (1963) reported greater vital capacity among younger men aged below 40 years compared to the older men aged over 60 years. Similar finding was made by Babb and Rodarte (2000) among the younger participants (aged 35-45years) compared to the older participants (aged 65-75 years). The results of some longitudinal study also exhibit that FVC and $FEV_{1.0}$ values declines with increasing of age (Love and Miller, 1982; Burrows et al., 1986; McClaran et al., 1995). However, very few data are available in Indian context regarding age related changes in lung function traits. Ghotkar et al. (1995) reported that lung function traits decrease with age among the sand stone quarry workers. Other studies reported a negative relation between peak expiratory flow rate (PEFR) and age (Jain et al., 1983; Mathur et al., 1996). Verma et al. (2002) also noted age related decline in lung function traits, which was more prominent after the age of 40 years.

In view of the above, present study tries to understand the nature of age related changes in lung function traits of the Santal stone mine workers of Birbhum district, West Bengal.

MATERIAL AND METHODS

The present data is a part of a large bio-medical project. Cross-sectional data have been collected from 328 (149 males, 179 females) healthy adult Santal stone mine workers under Md. Bazar police station area of Birbhum district, West Bengal, where stone mines are abundant in numbers. The study was restricted to single ethnic group (i.e. Santal) to avoid ethnic/genetic effect in respect of variables under study. Santals are the largest marginal community/ endogamous group (*schedule tribe*) of West Bengal, distributed in most of the districts (Census, 2001). They were classified as 'Pre-Dravidian' tribe. Their language, *Santali* belongs to the Mundari branch of Austro-Asiatic language family (Mukherjea, 1962) and now they have their own script i.e. '*Ol Chiki*.'

For the selection of study participants, no statistical samplings have been followed because of obvious difficulties in persuading the participants. Individuals who have been voluntarily agreed to participate with written consent have been included in the present study. This research was conducted after prior approval from the Ethical Committee for the Protection of Research Risks to Humans, Indian Statistical Institute, Kolkata.

Data on lung function traits includes variables like forced vital capacity (FVC), forced expiratory volume in one second ($FEV_{1.0}$), ratio of $FEV_{1.0}$/FVC and peak expiratory flow rate (PEFR) have been taken using battery operated portable spirometer (Hyngie, China). The FVC is the maximal volume of air exhaled from the lungs during a forced expiration after full inspiration. The $FEV_{1.0}$ is the volume of air exhaled in first second of the FVC manoeuvre and PEFR is the maximum flow rate during the same manoeuvre. The procedure of the test was demonstrated to each participant and each participant were allowed to practice and familiarise themselves with the procedure of test. After that, participants were asked to blow maximal forced expiratory manoeuvres from mouth in standing position provided the nose are closed and the best of three complete attempts were used in the analysis.

In the absence of birth records especially among the elderly individuals, ages of the study participants were estimated with reference to important local events and cross–checked with elderly individuals. Further the age was compared with the ages of individuals for whom age records existed to minimize the chance of error in reporting. The samples were classified into 5 age cohort (i.e. <25, 25-34, 35-44, 45-54 and 55+). The age cohort <25 was represented as group Gr. 1, 25-34 as Gr. 2, 35-44 as Gr. 3, 45-54 as Gr. 4 and 55+ as Gr. 5. However, it would have been ideal to classify individuals into 5 yearly age cohort, but due to small sample size it was not possible.

Data analysis

Descriptive statistics of all the lung function traits have been done. One-way analysis of variance (ANOVA) have been used to find out the differences between/ among five age

Table 1. Descriptive statistics of lung function traits of the stone mine workers

	Males (n=149)		Females (n= 179)	
	Mean	**SD**	**Mean**	**SD**
Age (yrs)	34.75	13.44	34.37	12.15
FVC (lit.)	2.63	0.54	1.79	0.40
$FEV_{1.0}$ (lit)	2.40	0.52	1.65	0.36
$FEV_{1.0}$/FVC	0.92	0.08	0.94	0.06
PEFR (lit/sec)	6.43	1.76	4.24	1.13

Table 2. Descriptive statistics of lung function traits by age cohorts of stone mine workers in either sex

Age cohorts (years)	**<25 Gr. 1**		**25-34 Gr. 2**		**35-44 Gr. 3**		**45-54 Gr. 4**		**55+ Gr. 5**		**ANOVA**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**F**	**p**
Males	***(n =38)***		***(n =51)***		***(n =22)***		***(n =20)***		***(n =18)***		***(df = 4, 144)***	
FVC	2.81	0.47	2.75	0.51	2.62	0.57	2.39	0.56	2.21	0.43	5.943	<0.001
$FEV_{1.0}$	2.67	0.44	2.56	0.42	2.28	0.48	2.09	0.55	1.89	0.33	14.136	<0.001
$FEV_{1.0}$/FVC	0.95	0.05	0.94	0.05	0.88	0.10	0.88	0.10	0.86	0.08	9.486	<0.001
PEFR	7.03	1.45	7.19	1.45	5.87	1.61	5.64	1.86	4.61	1.46	12.975	<0.001
Females	***(n =47)***		***(n =55)***		***(n =33)***		***(n =33)***		***(n =11)***		***(df =4, 174)***	
FVC	1.98	0.36	1.83	0.36	1.72	0.33	1.61	0.45	1.42	0.30	8.279	<0.001
$FEV_{1.0}$	1.85	0.34	1.71	0.33	1.60	0.26	1.42	0.33	1.34	0.28	12.056	<0.001
$FEV_{1.0}$/FVC	0.94	0.05	0.94	0.07	0.94	0.06	0.90	0.08	0.94	0.04	2.669	0.034
PEFR	4.40	1.24	4.26	1.05	4.48	1.10	3.75	1.13	3.92	0.64	2.490	0.045

cohorts in terms of mean of each lung function traits, separately for males and females. The significant ANOVA (F-values) results were further analysed with Scheffe's test (post-hoc) to find out exact difference between age cohorts. Scheffe's test is more conservative way of looking into the mean difference between groups and rules out type I error. Further, linear regression analysis has been done considering each lung function trait as dependent variable/s and age as independent variable of the stone mine workers. All the statistical analyses have been done using SPSS software 16.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Table 1 showed descriptive statistics of age and lung function traits of both male and female workers of the stone mine. The mean value of FVC, $FEV_{1.0}$ and PEFR were higher in male compared to female. On the other, the mean value of $FEV_{1.0}$/ FVC was higher in female than their male counterpart.

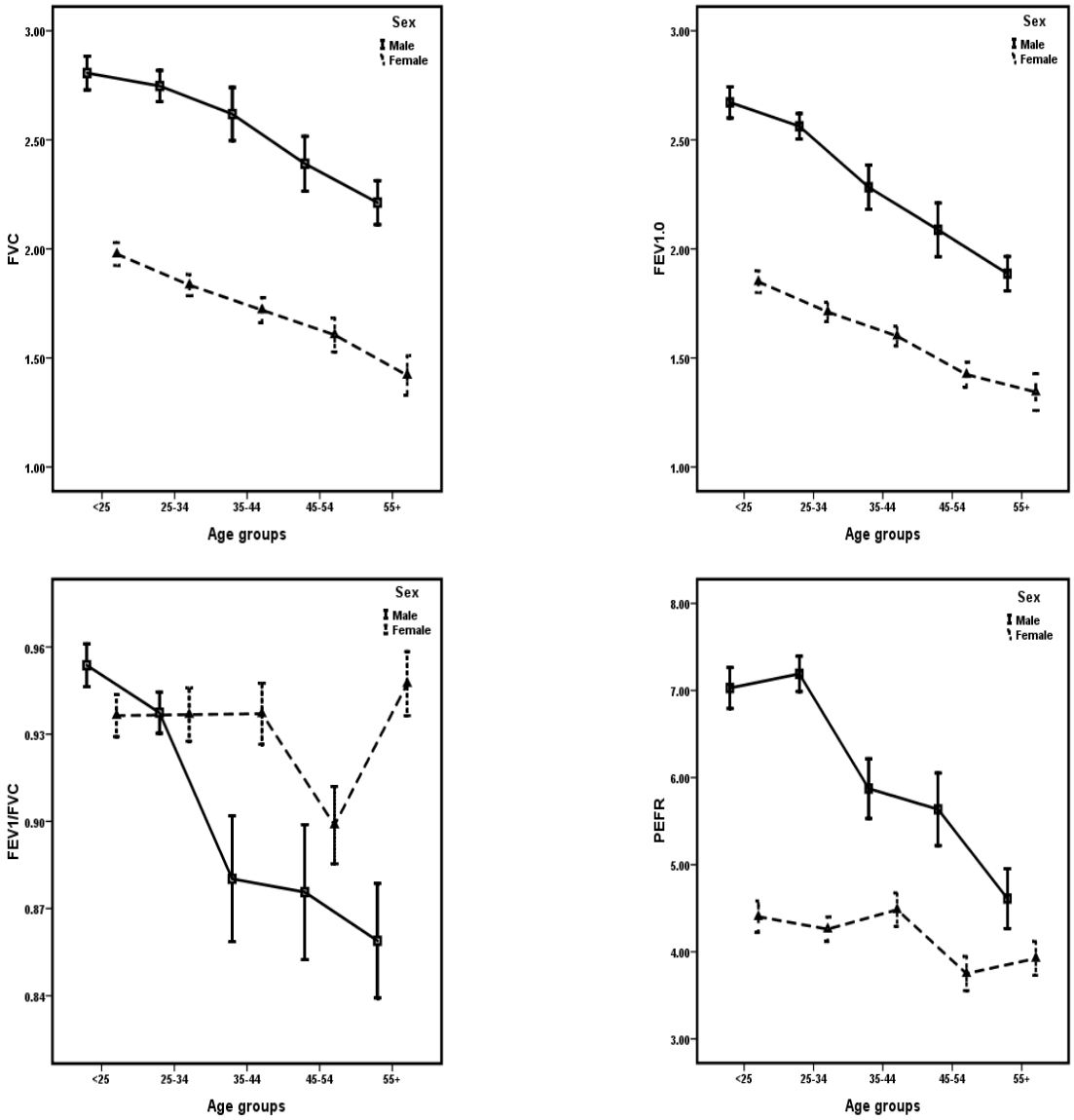

Figure 1. Age changes of lung function traits by different age cohorts of the stone mine workers

Table 2 showed descriptive statistics of lung function traits (FVC, $FEV_{1.0,}$ $FEV_{1.0}$/FVC and PEFR) by age cohorts of stone mine workers in either sex. Among males, the mean value of FVC, $FEV_{1.0}$ and $FEV_{1.0}$/FVC were highest in Gr. 1 (FVC= 2.81, $FEV_{1.0}$= 2.67 and $FEV_{1.0}$/FVC= 0.95) and lowest in Gr. 5 (FVC= 2.21, $FEV_{1.0}$= 1.89 and $FEV_{1.0}$/FVC= 0.86). On the other, the mean value of PEFR was maximum in Gr. 2 (7.19) and minimum in Gr. 5 (4.61). In females, the mean of both FVC and $FEV_{1.0}$ values were highest in Gr. 1 (FVC= 1.98 and $FEV_{1.0}$= 1.85) and lowest in Gr. 5 (FVC= 1.42 and $FEV_{1.0}$= 1.34). The mean value of $FEV_{1.0}$/FVC was more or less similar in all the groups and PEFR was highest in Gr. 3 (4.26). **Figure 1** also depicts trend line

Table 3. Scheffe's test (post hoc) between/among groups of stone mine workers in terms of lung function traits in either sex

	1 vs 2	1 vs 3	1 vs 4	1 vs 5	2 vs 3	2 vs 4	2 vs 5	3 vs 4	3 vs 5	4 vs 5
Males										
df	***87***	***58***	***56***	***54***	***71***	***69***	***67***	***40***	***38***	***36***
FVC	0.990	0.754	0.074	0.003*	0.912	0.141	0.007*	0.719	0.185	0.884
$FEV_{1.0}$	0.858	0.034*	<0.001*	<0.001*	0.198	0.003*	<0.001*	0.731	0.102	0.747
$FEV_{1.0}$/FVC	0.891	0.008*	0.005*	0.001*	0.051	0.036*	0.004*	1.000	0.929	0.972
PEFR	0.993	0.102	0.033*	<0.001*	0.027*	0.007*	<0.001*	0.993	0.158	0.380
Females										
df	***100***	***78***	***78***	***56***	***86***	***86***	***64***	***64***	***42***	***42***
FVC	0.443	0.057	0.001*	0.001*	0.738	0.101	0.024*	0.816	0.252	0.720
$FEV_{1.0}$	0.309	0.021*	<0.001*	<0.001*	0.647	0.003*	0.018*	0.284	0.256	0.971
$FEV_{1.0}$/FVC	1.000	1.000	0.139	0.991	1.000	0.111	0.992	0.189	0.994	0.291
PEFR	0.980	0.999	0.155	0.796	0.933	0.361	0.932	0.129	0.716	0.995

* $P \leq 0.05$

Table 4. Scheffe's test (post hoc) between/among groups of stone mine workers in terms of lung function traits in either sex

	Males		Females	
	Independent variable = age (years)			
Dependent variable	**Constant**	**β coefficient**	**Constant**	**β coefficient**
FVC (lit.)	3.168	-0.015	2.214	-0.012
$FEV_{1.0}$ (lit.)	3.119	-0.021	2.111	-0.013
$FEV_{1.0}$/FVC	1.004	-0.003	0.953	0.0006
PEFR (lit./sec)	8.649	-0.064	4.690	-0.014

of mean with error bar in lung function traits by age cohorts. The ANOVA result showed significant differences exists between/ among age cohorts in terms of mean of all the lung function traits for both males and females.

Table 3 showed the result of Scheffe's test of lung function traits between/ among age groups of the stone mine workers. In males, significant mean difference exists in FVC between Gr.1 vs. Gr.5 and Gr.2 vs. Gr.5. Significant difference exists in $FEV_{1.0}$ between Gr.1 vs. Gr.3, Gr.4 and Gr.5; Gr.2 vs. Gr.4 and Gr.5. Again, significant difference exists in $FEV_{1.0}$/FVC between Gr.1 vs. Gr.3, Gr.4 and Gr.5; Gr.2 vs. Gr.4 and Gr.5. PEFR shows significant differences between Gr.1 vs. Gr.4 and Gr.5; Gr.2 vs. Gr.3, Gr.4 and Gr.5. In females, significant difference exists in FVC between Gr.1 vs. Gr.4 and Gr.5; Gr.2 vs. Gr.5. Significant difference exists in $FEV_{1.0}$ between Gr.1 vs. Gr.3, Gr.4 and Gr.5; Gr.2 vs. Gr.4 and Gr.5.

Table 4 showed the result of linear regression analysis between lung function traits and age, considering lung function traits (FVC, $FEV_{1.0}$, $FEV_{1.0}$/FVC and PEFR) as dependent

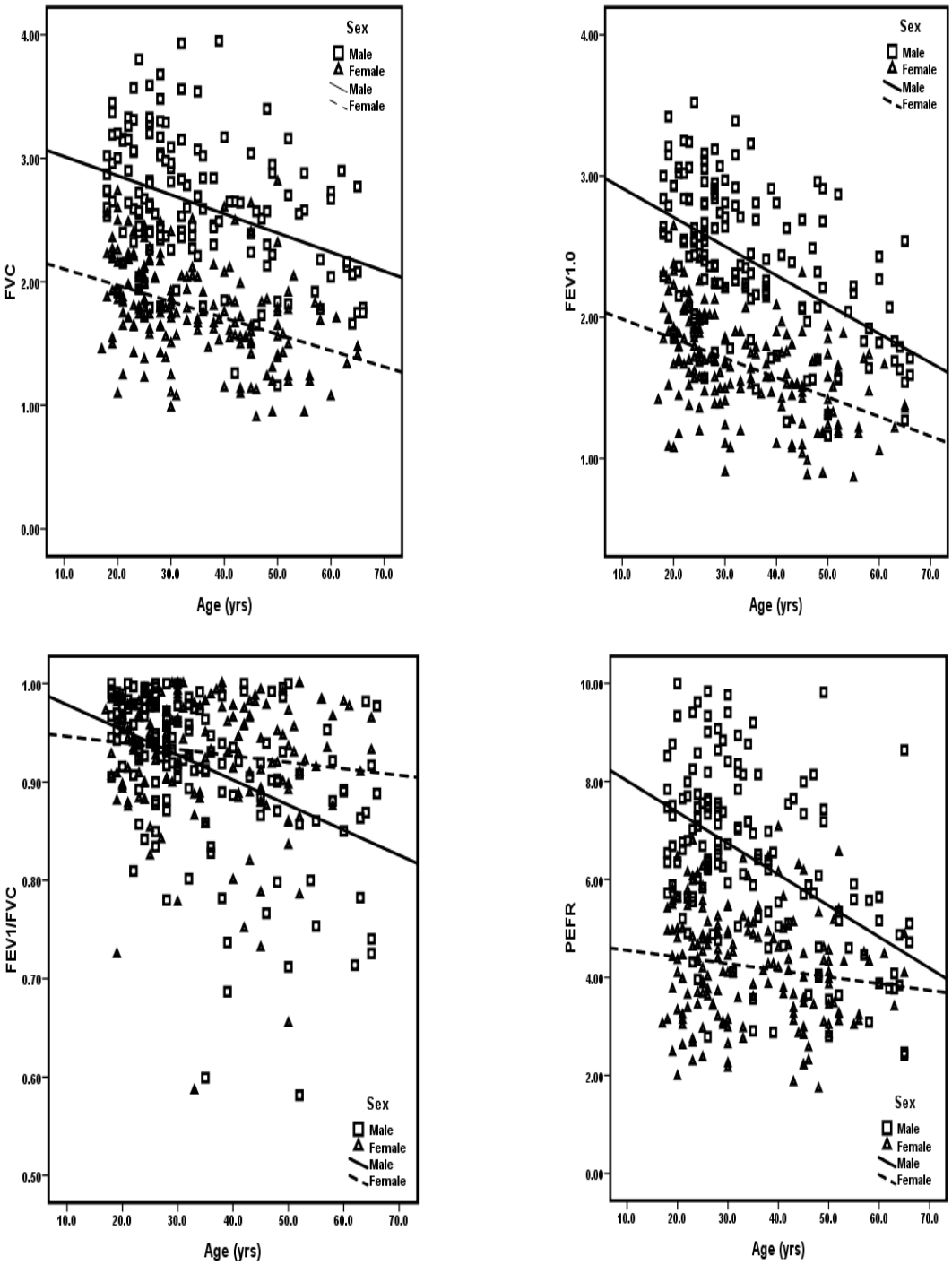

Figure 2. Scatter plot of lung function traits and age (years) of the stone mine workers

variable and age as independent variable. **Figure 2** depicts scatter plot with regression line separately for each lung function traits by age of both male and female stone mine workers.

DISCUSSION

The aim of the present study is to understand the age related changes in lung function traits (i.e. FVC, $FEV_{1.0}$, $FEV_{1.0}$/FVC and PEFR) of the Santal stone mine workers. The individuals of the present study were similar in terms of ethnicity, occupation, socio-economic condition and living in the same environmental set up. The test protocols for collection of data were similar for all the individuals and data were collected by single investigator (BM).

In order to identify the age-related changes in lung function traits, the individuals were classified into five age cohorts. Present study shows significant difference exists in lung function traits (FVC, $FEV_{1.0}$, $FEV_{1.0}$/ FVC and PEFR) between/ among age cohorts in both male and female mine workers. The mean value of both FVC and $FEV_{1.0}$ reached its peak below 25 years of age in both sexes and thereafter gradually declines. This finding corroborates with other studies (Kamat et al., 1982; Ghotkar et al., 1995; Mathur et al., 1998). Some earlier studies (Roy and Pal, 2003; Roy et al., 2015) conducted among the labourer groups of West Bengal also reported that most of the physiological traits including lung function reached its maximum value within 25 to 30 years of age and then declines. However, contrary to the present result, few studies reported that females reached their maximum volume of FVC and $FEV_{1.0}$ slightly earlier compared to their male counterpart (Kamat et al., 1982; Ghotkar et al., 1995). Again, the ratio of $FEV_{1.0}$/ FVC, both the sexes show decreasing trend with the progression of age and the pattern is more prominent in males than females. The ratio of $FEV_{1.0}$/FVC was relatively higher (approx. 90%) in either sex which corroborates with the findings of Green et al. (2008) studied among the stone crusher workers of Gwalior. The value of PEFR shows its peak between 25-34 years of age in male and between 35-44 years of age in female. This finding corroborates with the study of Tiwari et al. (2004), who observed that decline in PEFR after 35 years of age in both male and female quartz crusher workers of Rajasthan. The decline of PEFR was comparatively earlier in male than female workers that may be due their greater exposure to tobacco smoke (Cotes, 1979) as well as greater decline in respiratory muscle strength (Sharma and Goodwin, 2006). However, contrary to the present findings Jain et al., (1983) reported that female reached its highest PEFR value at the age of 21 years or so. And also noted that the additive effect of socio-economic condition and environmental factors including overcrowding, surrounding atmosphere and exposure to tobacco enhance the decline of PEFR.

The results of the present study exhibit lower mean value of both FVC and $FEV_{1.0}$ among the male workers compared to the male workers of other stone mine industries of India (Ghotkar et al., 1995; Mathur and Dixit, 1999; Tiwari et al., 2010). Similarly, female of the present study shows lower mean value of FVC and $FEV_{1.0}$ compared to the female workers of other stone mine industries of India (Ghotkar et al., 1995; Mathur et al., 1998; Tiwari et al., 2010). It may indicate that the values of lung function traits differ in different ethnic groups and each ethnic group has specific values of lung function traits (Harik-Khan et al., 2001).

Besides the participants of present study were mostly underweight with low BMI value (not presented in the table) which may influence the lung function by decreasing the respiratory muscle strength as well as decreasing the lung function capacity (Chen et al., 2007). Kamat et al., (1982) also pointed nutritional status as one of the important determining factor for lung function of the group.

CONCLUSION

Thus, the results of the present study indicate that highest value of lung function traits have been found before 25 years of age and then gradually decreases with progression of age, the pattern is similar in both male and female workers. However, it was not possible to determine the exact age when the lung function traits reached its peak and exactly when the values were declining, because of the small sample sizes in each age and the data was cross-sectional in nature. Though, the effect of concomitant factors like level of individual's performance of lung function, effect of anthropometric and other related variables like smoking habit as well as effect of malnutrition and poor socio-economic condition (primarily poverty) cannot be ruled out. Therefore, as a note of caution other researchers should take care in taking lung function measurement and more sample sizes are needed to make a clear understanding of the age related changes. Furthermore, different ethnic group may have different age specific changes in lung function traits that may also be explored in order to get better insights into the phenomena.

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AUTHOR'S CONTRIBUTIONS

Both the authors contributed equally to the manuscript writing. BM collected the data and SKR designed the study.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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