[Report]

Peak Expiratory Flow Rate of Jute Mill Workers in Calcutta

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Abstract : Ventilatory capacity of 32 control and 318 asymptomatic male jute mill workers of the Calcutta area, India was measured by Wright's Peak Flowmeter. Mean values of peak expiratory flow rate (PEFR) was 514 ± 66.41 l/min in Control and 475 ± 66.02 l/min and 462 ± 67.42 l/min in exposed non-smoker and smoker workers respectively. The relationship of PEFR with age, height, duration of exposure and smoking habit were studied. Multiple regression techniques were used to determine the form of the relationship of age, height, exposure and smoking habit with PEFR. The findings have been compared with those of Indian and foreign authors. The possible reasons of difference includes smoking habit, occupational exposure, physical background and residence in polluted area etc.

Key words: ventilatory capacity, peak expiratory flow rate, asymptomatic, regression, occupational exposure.

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Introduction

The Wright's Peak Flowmeter is a device for measuring peak expiratory flow rate (PEFR) introduced by Wright and Mckerrow in 1959 [1] for assessing ventilatory capacity. It has been used widely because of its accuracy and reproducibility. The apparatus is small and easy to manage, and it does not require any electric power to operate. Measurement of peak expiratory flow rate is specially suited for use not only at the bed side of the patient but in epidemiological surveys. It has also been used by clinicians in out-patient departments, chest clinics and in general practice. The PEFR has received general acceptance as a useful test of ventilatory capacity [2]. A number of studies [3, 4] have already shown the usefulness of this parameter (PEFR) for rapid determination of the pulmonary function or in evaluating changes in patients' degree of pulmonary disability. Compared with other instruments

which measure ventilatory capacity, the Wright's Peak Flowmeter has these above qualities and the speed with which the test is performed except a problem in effort dependent for subjects. Evaluation of PEFR requires knowledge of its range in normal subjects of the same sex, age and occupation. However, there is still uncertainty among scientists regarding the normal values of PEFR. The present study was undertaken to report the PEFR of 32 control subjects not exposed to the jute mill and 318 asymptomatic jute mill workers within the age range of 21–55 years and 21–60 years respectively. Regression equations have been calculated for the purpose of predicting the values of PEFR of different populations. Possible reasons are discussed for the differences between our findings and those of other authors.

Materials and Methods

The subjects of the present study were asymptomatic healthy male jute mill workers. Data were available on 32 control subjects taken from the office staff, securities and maintenance staff of the same jute mill, and of the same socioeconomic status, having no respiratory complaint and smoking history, and 318 asymptomatic jute mill workers. Measurements of PEFR were made on two standard model Wright's Peak Flowmeter and the same technician completed the whole experiment. These instruments were calibrated by the manufacturer and checked every day by measuring our own PEFR before starting the experiment. It was measured in standing position with a nose clip. Among these workers all control subjects were non-smokers and among the jute mill workers 166 workers were non-smokers and 152 smokers all current smokers. The purpose and technique of the test was explained to every subject and this was followed by a demonstration of its performance. After two to three trials the subject was exhorted to make a maximal effort and was closely watched to ensure that the person maintained an airtight seal between the lips and the mouthpiece of the instrument. The highest value of PEFR achieved in three to five successive attempts were recorded and taken for calculation. A disposable mouthpiece was used for each subject. Standing height was measured on a standard scale after the removal of shoes. The age was recorded by asking and according to the joining registrar of the mill. Smoking and occupational history of the workers were recorded by a questionnaire method to the extent that it was practicable. All control subjects were non-smokers and had no history of respiratory disease during childhood and are free of any other respiratory diseases at present. In the case of the jute mill workers only asymptomatic workers were taken for the study.

Results

Table 1 represents the physical characteristics and peak expiratory flow rate of the control and asymptomatic jute mill workers. PEFr values of the control subjects were compared with exposed non-smokers, smokers and the

Table 1. Physical measurement and peak expiratory flow rate of control and exposed workers (Mean $\pm$ SD)

	Smoking habit	Age (yrs)	Height (cm)	PEFR (ℓ /min)	PEFR (ℓ /min) of the entire series
Control N=32	NS N=32	39 ± 9.05	167 ± 6.22	514 ± 66.41	514 ± 66.41
Exposed N=318	NS N=166	40 ± 9.93	165 ± 6.20	475 ± 66.07	469 ± 66.41
	S N=152	42 ± 8.10	165 ± 5.70	462 ± 67.42	

NS=Non-smoker; S=Smoker

Table 2. PEFr (ℓ /min) of the jute mill workers according to duration of exposure (Mean $\pm$ SD)

Exposure (yrs)	Smoking habit	Batching	Spinning	Weaving	Winding	Beaming	Finishing	General
Up to 10	NS	580 ± 63.63 (2)	493 ± 52.51 (6)	463 ± 74.30 (8)	470 ± 56.56 (2)	565 ± 35.35 (2)	400 ± 9.00 (1)	523 ± 46.45 (3)
		523 ± 24.74 (2)	553 ± 116.67 (2)	515 ± 0.00 (1)	453 ± 45.96 (2)	500 ± 42.42 (2)	000 ± 0.00 —	483 ± 38.89 (2)
	S	439 ± 61.38 (19)	490 ± 52.98 (6)	493 ± 60.58 (22)	498 ± 58.15 (5)	532 ± 52.04 (3)	486 ± 62.72 (13)	483 ± 72.50 (6)
		470 ± 27.38 (5)	454 ± 77.31 (9)	480 ± 75.60 (16)	513 ± 50.17 (6)	467 ± 43.38 (5)	484 ± 73.68 (5)	523 ± 32.51 (5)
11—20	NS	434 ± 60.11 (7)	464 ± 58.45 (8)	474 ± 68.75 (17)	433 ± 53.46 (3)	432 ± 144.95 (2)	432 ± 60.70 (8)	488 ± 40.97 (10)
		431 ± 47.24 (14)	455 ± 39.62 (12)	466 ± 74.34 (15)	448 ± 65.11 (10)	424 ± 44.60 (4)	438 ± 60.12 (7)	489 ± 57.78 (11)
	S	400 ± 0.00 (1)	410 ± 0.00 (1)	449 ± 72.67 (7)	460 ± 0.00 (1)	533 ± 10.60 (2)	475 ± 7.07 (2)	320 ± 0.00 (1)
		465 ± 35.35 (2)	340 ± 0.00 (1)	449 ± 84.73 (5)	415 ± 70.71 (2)	300 ± 0.00 (1)	355 ± 55.67 (5)	000 ± 0.00 —

NS=Non-smoker; S=Smoker

Figures within the parenthesis indicate the number of subjects.

workers of the entire series showed highly significant differences ($P < 0.01$, $P < 0.001$ and $P < 0.001$). But the difference between exposed non-smokers and smoker workers are statistically non-significant.

Table 2 depicts the PEFr values of the non-smoker and smoker jute mill workers of different departments according to their duration of exposure. In most of the departments exposed non-smoker workers had higher PEFr values than the smokers, but the differences were statistically non-significant. In weaving, spinning and winding, the smoker workers had higher values than the non-smokers. The distribution of workers of some departments was very much less and dissimilar. Changes of PEFr according to smoking habit among different groups of jute mill workers are presented in Table 3. In

Table 3. PEFr (ℓ/min) of jute mill workers according to smoking habit (Mean $\pm$ SD)

Process	Smoking habit	No. of subject	Age (yrs)	Height (cm)	PEFr (ℓ/min)	Entire series (ℓ/min)
Control N=32	NS	32	39 ± 9.05	167 ± 6.22	514 ± 66.40	514 ± 66.40
Batching N=47	NS	24	41 ± 9.19	163 ± 5.30	448 ± 70.52	449 ± 59.54
	S	23	45 ± 7.16	164 ± 5.97	451 ± 48.46	
Spinning N=47	NS	23	35 ± 10.27	163 ± 6.81	478 ± 54.72	468 ± 63.00
	S	24	39 ± 8.88	163 ± 5.75	458 ± 69.37	
Weaving N=91	NS	54	40 ± 10.57	166 ± 5.90	477 ± 66.75	475 ± 69.43
	S	37	42 ± 6.88	166 ± 6.05	471 ± 74.12	
Winding N=31	NS	11	39 ± 10.63	165 ± 8.68	472 ± 55.19	467 ± 60.05
	S	20	41 ± 8.66	165 ± 4.59	464 ± 64.79	
Beaming N=21	NS	9	42 ± 11.83	167 ± 4.27	526 ± 67.76	479 ± 65.55
	S	12	39 ± 8.72	165 ± 5.24	444 ± 65.08	
Finishing N=41	NS	24	41 ± 7.85	163 ± 4.79	464 ± 63.25	449 ± 71.54
	S	17	46 ± 7.35	165 ± 6.24	427 ± 78.58	
General N=38	NS	20	43 ± 8.60	167 ± 6.80	483 ± 63.81	490 ± 56.54
	S	18	42 ± 8.67	166 ± 5.38	498 ± 50.64	

NS=Non-smoker; S=Smoker

Table 4. Level of significance of PEFR of jute mill workers with smoking habit

	Control (NS)* Vs Exposed (NS)*	Control (NS)* Vs Exposed (S)	Control (NS)* Vs Exposed (NS+S)	Exposed (NS)* Vs Exposed (S)
Batching N=47	<0.001	<0.001	<0.001	NS
Spinning N=47	<0.05	<0.01	<0.01	NS
Weaving N=91	<0.05	<0.05	<0.01	NS
Winding N=31	<0.05	<0.01	<0.01	NS
Beaming N=21	NS	<0.01	NS	<0.05
Finishing N=41	<0.01	<0.001	<0.001	NS
General N=38	NS	NS	NS	NS

NS*=Non-smoker; S=Smoker; NS=Non-significant

almost all departments the changes between control workers and exposed non-smokers and smokers and the workers of the whole series showed a significant difference, but the changes in non-smoker and smoker workers of the same exposed group were found statistically non-significant. The level of significance of PEFR among non-smoker and smoker workers of different departments are presented in Table 4.

Fig. 1 PEFR (l/min) of control subjects and asymptomatic jute mill workers, according to age range.

- WORKSM: Smoker jute mill workers.
- WORKNS: Non-smoker jute mill workers.
- CONTROL: Control subjects.

Figure 1 represents the values of the control and exposed workers according to different age groups by decade. There were two exposed and one control subject who were below 21 years of age, so they were not considered in the calculation. Among control and exposed workers the PEFR values were reduced as age was increased. Control subjects showed a significant difference ($P < 0.05$) of values when a comparison was made between the age groups of 21–30 years and 31–40 years. But a mean difference of values was found in each comparison when the lower and higher age groups were compared. Figure 2 represents the PEFR of control and jute mill workers according to the different height ranges. In these workers the PEFR values were increased as height range was increased. Table 5 represents the regression equations and standard error of estimate (SEE) for control subjects and jute mill workers (non-smokers and smokers) of the age range of 21–55 years and 21–60 years respectively. Three regression lines have been drawn for these subjects. Figure 3 represents the regression lines of the control and jute mill workers. A multistage step-wise analysis was performed for both types of subjects to determine the form of the regression of PEFR on age, height and exposure. When the data were plotted, it shows that the relation between PEFR and age was curvilinear in control subjects. The powers of age, up to $(\text{age})^4$ were included in the regression and the procedure of backward elimination was used to determine the final model.

Fig. 2 PEFR (ℓ/min) of control subjects and asymptomatic jute mill workers, according to height range.

WORKSM: Smoker jute mill workers.
 WORKNS: Non-smoker jute mill workers.
 CONTROL: Control subjects.

Fig. 3 Regression lines for PEFR (ℓ/min) of control subjects and non-smoker and smoker jute mill workers, standardised for age and height.

- CONTROL: Control subjects.
 + WORKNS: Non-smoker jute mill workers.
 ◇ WORKNS: Smoker jute mill workers.

Table 5. Regression, equation of PEFR $\text{PEFR } (\ell/\text{min}) = b_0 + b_1\text{age} + b_2\text{age}^2 + b_3\text{height}$

	Control subject (21–55 yrs)	Jute mill workers (non smoker) (21–60 yrs)	Jute mill workers (smokers) (21–60 yrs)
b_0	–43.3019	61.0531	–15.0551
b_1	8.7745	– 1.8491	– 2.5336
b_2	– 0.1553	–	–
b_3	2.7718	2.9539	3.5572
Standard error of estimate (Std. after regression)	42.97	57.03	56.71

Their regression lines have been drawn using the standardised height of 166 cm.

All the variables which seem to be related to PEFR were initially included and then eliminated in turn if their additional contribution to the regression sum of squares was not statistically significant. At each stage the variable rejected whose partial co-efficient of determination did not differ significantly from zero. Considering these data of the control subjects, it was found that the three

Table 6. Comparison of age and height standardised values of PEFR (ℓ/min) of control subjects in different studies from India and abroad

Name of authors		Place of study	Predicted values (ℓ/min)
Kamat <i>et al.</i>	[15]	Southern India	516
Chatterjee <i>et al.</i>	[12]	Eastern India (Non-smoker)	559
Chatterjee <i>et al.</i>	[12]	Eastern India (Smoker)	543
Behara <i>et al.</i>	[13]	Orissa Tribal	556
Malik <i>et al.</i>	[16]	North Indian Adults	513
Woolcock <i>et al.</i>	[17]	African coastal	508
Selby <i>et al.</i>	[11]	Australian	524
Gregg <i>et al.</i>	[15]	British	617
Present study		Eastern Indian (Non-smoker)	514

Standardized for age 40 years and height 166 cm.

factors age, $(\text{age})^2$ and height contributed significantly to the model, whereas the higher power of age beyond $(\text{age})^2$ did not significantly improve the model. In non-smoker and smoker jute mill workers the significant factors are age and height but the higher powers of age even $(\text{age})^2$ was not a significant factor. Therefore, the relation between PEFR and age in these cases was indicated by a straight line. The duration of exposure to the jute mill made no additional contribution to the regression model that its partial co-efficient of determination was not statistically significant. It accounted for 0.002% in smokers and 0.001% in non-smokers of the total variation which age and height had failed to explain for non-smoker and smoker jute mill workers respectively.

Table 6 depicts the age and height standardized values of PEFR of control subjects of different regions of India and abroad.

Discussion

The regression equations for PEFR on age and height was assumed that there was a linear relation between the fall of PEFR and increasing age [5]. A similar assumption was made by nearly all other authors who have published the normal values of PEFR [6]. A linear fall of PEFR can occur only after the age at which maximal PEFR is attained and if the adolescents are included in the series, the shape of the regression must be curvilinear. Singh and Peri [7], reported that peak flow declines with age, beyond the third decade. According to Gregg and Nunn [5], in both sexes PEFR does not begin to decline until about the age of 35 years. Very similar findings were reported by Brooks and Walter [8]. In the present study similar findings were noted and it was found that the PEFR values declined from the age of the third decade.

Fairbrain and co-workers [9] reported that the normal persons' mean reading of PEF_R was 537 ℓ /min. The mean blowing was found to decline 0.29 unit for each year increase in age and for each extra inch of height the blow increased by 1.44 units. Weight had no significant effect. In the present study control subjects and jute mill workers had lower PEF_R values than their study. Shepard [10] investigated the PEF_R values of 72 normal subjects whose PEF_R values ranged from 300 – 700 ℓ /min. Our observed values are within that limit. Brooks and Walter [8] and Gregg and Nunn [5] reported on PEF_R of British subjects, and the report by Selby *et al.* [11] for Australian subjects showed that PEF_R was much higher than that of the present study. The higher PEF_R in western subjects appears to be partly due to their larger physical build. Chatterjee *et al.* [12] reported higher values in Eastern regional peoples in their study, because their subjects belonged to higher socio-economic groups. Behara *et al.* [13] reported that scheduled tribe (Non-smoker) subjects have higher mean values due to a well built body, physically active habits and living in a pollution free environment.

The jute mill workers showed significantly lower values in different age and height ranges irrespective of smoking habit in comparison to the control subjects. In control subjects of the higher age group (50–55 years) the mean values of PEF_R were less than the non-smoker and smoker jute mill workers. Only three control workers were present in that age group and their values were lower, which might be due to a less number of subjects and highly personal variation of the parameter (PEF_R). But few of the mean differences of values shown between the non-smoker and smoker exposed workers reached a significant level. Rastogi *et al.* [14] studied the PEF_R of industrial male workers, and his predicted values were higher than our observed values of non-smokers, smokers and mixed workers. Our regression equations for PEF_R were obtained by the method of least square deviation. Therefore, powers of age up to $(\text{age})^2$ were included in the regression and procedure of backward elimination was used to determine the final model. In control subjects the relation is curvilinear whereas in jute mill workers the significant factor is only age and height, even $(\text{age})^2$ is not significant factor that's why the relation of PEF_R is a straight line. All the variables were initially included and then eliminated as their additional contribution to the regression sum of squares was not statistically significant. All the probable factors were considered which are significantly correlated with PEF_R. Among 19% of the non-smoker jute mill workers and 22% of the smoker jute mill worker there were explainable total variation of PEF_R values, whereas the same figure for control workers was 52%. This parameter can be widely used on non occupational, occupational subjects and patients to evaluate the ventilatory capacity. The developed

regression equations for PEFR will be very helpful to predict the parameter of control subjects and asymptomatic jute mill workers in clinical practice and field study.

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カルカッタのインド麻工場における労働者のピークフロー (PEFR)

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要 旨: インドのカルカッタ地域において, 32 人の対照群と, 318 人のインド麻工場労働者 (無症状の者) に対して, ライト式ピークフローメーターで換気能力を測定した. 対照群では, ピークフローの平均値は, 514 ± 66.41 l/分であり, 労働者の中で非喫煙者は 475 ± 66.02 l/分, 喫煙者は 462 ± 67.42 l/分であった. ピークフローの値と年齢, 身長, 工場での曝露期間, および喫煙との関連性を重回帰分析を用いて検討した. 得られた結果を, インドおよび諸外国からの報告と比較すると共に, 喫煙習慣, 職業性曝露, 身体的背景, あるいは汚染地域内での居住, などの要因の及ぼす影響を考察した.

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