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Original Research Article

A study on differences in peak expiratory flow rate among school children of age 7-12 years at different altitudes of Darjeeling and Purulia district of West Bengal

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ABSTRACT

Background: The peak expiratory flow rate (PEFR) is an effort-dependent parameter, which reflects large airway flow, voluntary and muscle strength. High altitudes may have an impact on peak expiratory flow rate, owing to hypoxia, low air density and increased muscular activity, The study was conducted to find out the variance of PEFR among healthy school children of high and low altitude region.

Methods: This cross-sectional study was conducted at different altitudes and schools of Darjeeling and Purulia district, taking a total of 400 healthy school going children aged between 7-12 years. The age, weight and height of the children were calculated and the PEFR was recorded in standing position. The data was entered in MS Excel and analyzed using the SPSS version 20.0 software.

Results: The mean height, body mass index (BMI) and SpO2 was lower among high altitude children, while their PEFR values were higher. These findings were observed to be statistically significant. Further, females were observed to have a lower PEFR value than their male counterparts.

Conclusion: The PEFR values of low altitude children were significantly lower than the high altitude children.

Keywords: Altitude, Darjeeling, Peak expiratory flow rate, Purulia, School children, West Bengal

INTRODUCTION

The peak expiratory flow rate (PEFR) is the maximum flow rate generated during a forceful expiration starting from a full lung inflation. It emerges from the large airways within about 100-120 msec of the start of forced expiration and remains at its peak for 10 msec.[1] Measuring PEFR is an easy procedure which reflects large airway obstruction and voluntary effort. Several factors like age, sex, anthropometric measurements (e.g., height, weight, body surface area), socioeconomic status, smoking, overcrowding, occupational exposure are known influential factors of peak expiratory flow rate.[2-4] At high altitudes, a number of acute and chronic airway mechanisms are activated, which are aimed at optimizing oxygen availability.[5] Large number of people in India are living in high altitude region and are facing mosaic of harsh environmental conditions like hypoxia, cold, higher radiation exposure and rugged surface, leading to increased exercise every day for their livelihood.

The low air density at high altitudes may result in hypoxia, thereby leading to a compensatory rise in muscular activity. It should have an impact on PEFR, although it has not been proved decisively. This information may help us to screen school children early for obstructive airway diseases and find out the target group. The present study was planned with overall objective to find out the difference of peak expiratory flow rate among school children of high-altitude region of Darjeeling district and low altitude school children of both Darjeeling and Purulia district.

METHODS

Study design

An observational, community based analytical study with cross sectional design was conducted.

Study place

School of Darjeeling district at different altitudes and school of Purulia district. Children of selected schools of Darjeeling and Purulia district at a point of time between the stipulated study duration.

Study duration

Necessary data for the study were collected from February 2020 to July 2021.

Study population

Healthy school children of age 7-12 years were the study population.

Inclusion criteria

Children aged between 7-12 years. All school going healthy children. Consent obtained from parent and school were included.

Exclusion criteria

Children with medical illness like, children with wheezing. Children with visible bony deformity and muscular deformity of chest wall. History of cardiac and respiratory chronic disease. History of medications like anti-asthmatics and recurrent hospital admission. History of recent respiratory infection within 3 weeks prior to study

Sample size

After applying the inclusion and exclusion criteria, a total of 400 children divided from both the district of Darjeeling and Purulia (200 children from each district) aged between 7-12 years during the study period were approached and enrolled in this study using complete enumeration method.

Sampling technique

Sampling technique used is multistage cluster sampling where 100 children from each cluster group of plain area of Darjeeling district i.e., Siliguri subdivision area and plain area of Purulia district i.e., Raghunathpur subdivision area were taken, they were subdivided in 2 subcluster group of age 7-9 years and 10-12 years group. On the other hand, 100 children from each cluster group of high-altitude area of Darjeeling district i.e. Sevok, Kurseong and Darjeeling area with near equal participation from each area with subcluster group of 7-9 year and 10-12 year selected and 100 children selected from high altitude area of Purulia district i.e., Baghmundi with sub cluster group of age 7-9 year and 10-12 year as per voluntary response method.

Study tools

Pretested semi structured schedule, weight machine standard calibrated bathroom scale digital, standard portable stadiometer, Mini Wright peak flowmeter, stethoscope, pulse oximeter, portable aneroid barometer, portable wall mountable room thermometer

Study techniques

This study was conducted after taking clearance from Institutional Ethics Committee. Consent was obtained from the parents/guardian and interview of the study subjects was conducted using the predesigned and pretested schedule. Then, physical examination was done.

Age

Age was calculated to the nearest completed year.

Weight

Weight (in kg) was measured without shoes and with light clothing, on a standard calibrated bathroom scale.

Height

Height (in cm) was measured with a standard portable stadiometer.

Peak expiratory flow rate

PEFR values were then recorded in standing position. The maneuver was explained and demonstrated to them before the actual recording. Each child was asked to take a deep breath and then blow into the peak flow meter as maximum and quickly as possible. The marker was then returned to zero after every measurement. Every child was given two trial runs and encouraged to blow harder each time. Three measurements were taken and the highest reading among them was recorded. A tight seal was maintained between the lips and the mouthpiece. Disposable mouth piece were used for each subject.

The measured values of PEFR of all children were standardized to body temperature and ambient pressure saturated (BTPS), before analyzing them statistically, by applying the following correction equation for PEFR, suggested by Pederson et al.[6]

PEFc = (2×K1/ (D×K2))0.5×(PEF m1.5/K2+A0×PEF m 0.5).

Where, PEFm is the measured PEFR value. PEFc is the corrected PEFR value. D is density of air. A0, K1, and K2 are constants, whose values are 0.25 cm,1.42 kPa/cm^2, and 435 l/min/cm^2, respectively. The density of air (D) was calculated from another equation suggested by Pederson et al.

D=1.293×B×273/(T×101.3)

Where, Constant 1.293 is the density of air in kg/m3 (at a temperature of 273 Kelvin and a pressure of 101.3 kPa). B is the ambient pressure (kPa; measured with a portable aneroid barometer). T is the ambient temperature (measured in Kelvin with a portable, wall-mountable, alcohol-based room thermometer).

Statistical analysis

Data were entered into MS Excel and analyzed using the SPSS version 20. Descriptive analysis was done in the form of proportion for categorical variables, mean or median for continuous variables. The difference between proportions was analyzed using Chi square test p value of less than 0.05 was considered statistically significant. Data were checked for normal distribution using tests for normality and non-parametric test was performed accordingly. Correlation between parameters of age, height, weight, SpO2 and PEFR were shown using Spearman's correlation coefficient, p value of less than 0.05 was considered statistically significant.

RESULTS

Among a sample size of 400 children, with 200 each in low altitude and high-altitude areas (Table 1), the 7-9 years age group comprised of 100 children (49.3%) living in low altitude areas, while 103 (50.7%) resided at high altitudes. In the 10-12 years age group, 100 children (50.8%) were from the lower altitudes while 97 (49.2%) lived-in high-altitude areas. The mean age among the low altitude children was 9.49±1.7 while that among high altitude children was 9.43±1.7 years. A total of 97 females (49.2%) belonged to low altitude area with 48 (49.5%) in the 7-9 years age group and 49 (50.5%) in 10-12 years age group, 100 females (50.8%) belonged to high altitude areas with 52 (52%) in the 7-9 years age group and 48 (48%) in the 10-12 years age group. 103 (50.7%) males resided in low altitude with 52 males (50.5%) in 7-9 years age group and 51 (49.5%) in 10-12 years age group, and 100 males (49.3%) in high altitude areas with 51 (51%) in 7-9 years age group and 49 (49%) in 10-12 years age group.

Table 2 shows that the average height for females aged 7-9 in the low-altitude area was 124.21±5.22 cm, while for males it was 125.21±4.70 cm. For the same age group in the high-altitude area, females had a mean height of 121.19±5.74 cm, and males measured 138.42±5.95 cm. In the 10-12 age group, the mean height of females in the low-altitude area was 140.82±4.84 cm, with males slightly taller at 141.59±5.17 cm. At high altitude, the mean height of females in this age group was 123.27±5.77 cm, while males were measured at 139.10±6.02 cm.

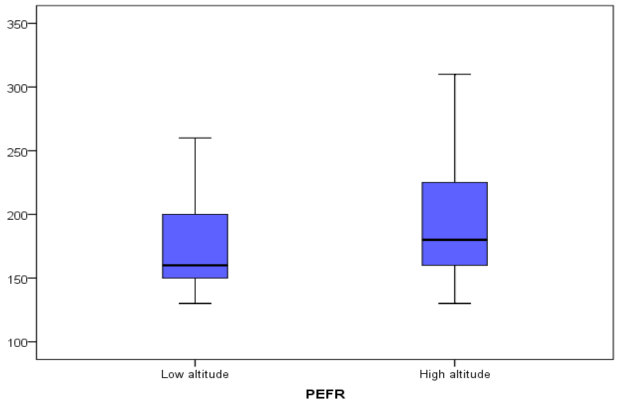

Figure 1: The distribution of PEFR among the study subjects (n=400).

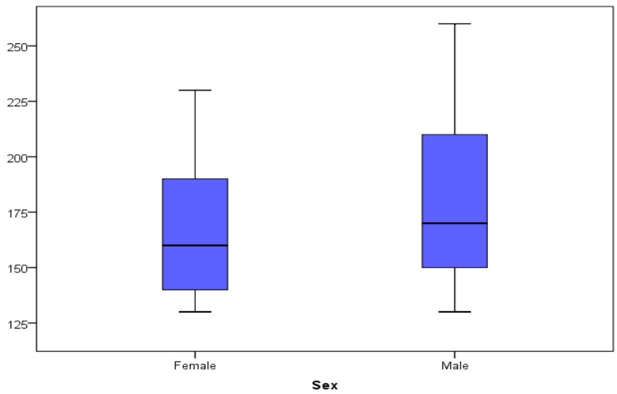

Figure 2: The distribution of PEFR among the low altitude children by sex (n=200).

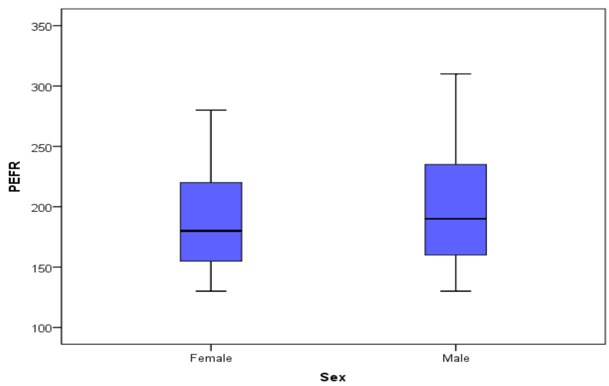

Figure 3: The distribution of PEFR among the high-altitude children by sex (n=200).

Figure 1, show that the mean (SD) and median (Inter-quartile range) PEFR among the low altitude children was 172.40 (33.80) and 160 (150, 200); while among the high-altitude children the PEFR was higher, 194.10 (43.28) and 180 (160, 227.50). This difference in the PEFR among the group was statistically significant (Mann Whitney U test, p value <0.001). Figure 2, show that at the low altitude children, the mean (SD) and median (Inter-quartile range) PEFR among the female was 167.42 (31.50) and 160 (140, 195); while among the male children the PEFR was higher, 177.09 (35.35) and 170 (150, 210). This difference in the PEFR among the gender was statistically significant (Mann Whitney U test, p value -0.037). Figure 3, show that at the high-altitude children, the mean (SD) and median (Inter-quartile range) PEFR among the female was 187.40 (40.21) and 180 (152.50, 220); while among the male children the PEFR was higher, 200.80 (45.36) and 190 (160, 237.50). This difference in the PEFR among the gender was statistically significant (Mann Whitney U test, p value -0.036).

The average weight for females aged 7-9 in the low-altitude area was 23.10±2.72 kg, while males weighed slightly more at 23.73±2.47 kg. In the high-altitude area, females of the same age had a mean weight of 23.28±3.91 kg, and males weighed 24.02±3.89 kg. In the 10-12 age group, the mean weight for females in the low-altitude area was 35.61±40.4 kg, compared to 35.57±4.01 kg for males. At high altitude, females in this group weighed 34.39±5.21 kg, and males weighed 34.55±4.84 kg. Regarding BMI, females aged 7-9 in the low-altitude area had a mean of 14.92±0.95, while males had a slightly higher mean of 15.07±0.67. In the high-altitude area, the mean BMI for females was 15.72±1.47, and for males it was 15.69±1.37. In the 10-12 years age group, the average BMI for females in the low-altitude area was 17.89±0.99, and males had a mean of 17.68±0.89. Meanwhile, at high altitude, females in this group had a mean BMI of 17.83±1.48, and males had a BMI of 17.74±1.21. The mean SPO2 for females aged 7-9 in the low-altitude area was 97.60±0.73, and for males it was 97.73±0.81. At high altitude, females of the same age had a mean SPO2 of 97.21±0.87, with males at 97.31±0.73. In the 10-12 age group, the mean SPO2 for females in the low-altitude area was 98.57±0.86, identical to that of males. At high altitude, females had a mean SPO2 of 97.46±1.39, while males showed a mean of 97.02±1.31. For PEFR, the mean value for females aged 7-9 in the low-altitude area was 141.87±9.81, while males had a mean of 149.81±11.63. In the high-altitude area, females had a mean PEFR of 157.50±18.56, and males had a higher mean at 169.22±22.25. Among the 10-12 age group, females in the low-altitude area had a mean PEFR of 192.45±24.45, while males measured 204.90±29.14. In the high-altitude area, females had a mean PEFR of 219.79±31.18, and males had 233.67±39.56.

The mean (133) and median height (133) of children was higher as compared to those of high-altitude children (130.25 and 130 respectively). This difference was found to be statistically significant with a p value of 0.008. Similar findings were observed for SpO2 where the mean (98.12) and median (98) SpO2 was higher among low altitude children as compared to high altitude children, who's mean SpO2 was 97.25 and median was 97, this difference being statistically significant with p value <0.001. But the mean and median BMI was higher for high altitude children (16.71 and 16.79 respectively) compared to low altitude children (16.39 and 16.29 respectively). This finding was again statistically significant with a p value of 0.030 (Table 3 and Figure 1,2 and 3). However, no statistical significance was observed in the mean and median weights of low altitude and high-altitude children, although the mean and median values of the former were higher (29.51 and 29 respectively). Table 4, reveals that when age, height, weight, SpOO2 and PEFR was correlated, it was statistically significant (p value <0.05).

Table 1: Demographic characteristics of study variables (n=400).

Age (in years)	**Low altitudes (n=200) n (%)**	**High altitudes (n=200) n (%)**	**χ^2 value (df)*, p value (*Chi square value, Degree of freedom)**	
7-9	100 (49.3)	103 (50.7)	0.090, 1, 0.764	
10-12	100 (50.8)	97 (49.2)		
Total	200 (100)	200 (100)		
Sex	Low altitudes (n=200) n (%)	High altitudes (n=200) n (%)		
Female	97 (49.2)	100 (50.8)	0.090, 1, 0.764	
Male	103 (50.7)	100 (49.3)		
Total	200 (100)	200 (100)		
Age (in years)	**Low altitude**		**High altitude**	
	Female	**Male**	**Female**	**Male**
7-9	48 (49.5)	52 (50.5)	52 (52)	51 (51)
10-12	49 (50.5)	51 (49.5)	48 (48)	49 (49)
Total	97 (100)	103 (100)	100 (100)	100 (100)

Table 2: Examination findings among the study population (n=400).

Age (years)	Low altitude Mean (SD) height		High altitude Mean (SD) height	
	Female	Male	Female	Male
7-9	124.21 (5.22)	125.31 (4.70)	121.19 (5.74)	138.42 (5.95)
10-12	140.82 (4.84)	141.59 (5.17)	123.27 (5.77)	139.10 (6.02)
Age (in years)	**Low altitude Mean (SD) weight**		**High altitude Mean (SD) weight**	
	Female	**Male**	**Female**	**Male**
7-9	23.10 (2.72)	23.73 (2.47)	23.28 (3.91)	24.02 (3.89)
10-12	35.61 (4.04)	35.57 (4.01)	34.39 (5.21)	34.55 (4.84)
Age (in years)	**Low altitude Mean (SD) BMI**		**High altitude Mean (SD) BMI**	
	Female	**Male**	**Female**	**Male**
7-9	14.92 (0.95)	15.07 (0.67)	15.72 (1.47)	15.69 (1.37)
10-12	17.89 (0.99)	17.68 (0.89)	17.83 (1.48)	17.74 (1.21)
Age (in years)	**Low altitude Mean (SD) SpO2**		**High altitude Mean (SD) SpO2**	
	Female	**Male**	**Female**	**Male**
7-9	97.60 (0.73)	97.73 (0.81)	97.21 (0.87)	97.31 (0.73)
10-12	98.57 (0.86)	98.57 (0.83)	97.46 (1.39)	97.02 (1.31)
Age (in years)	**Low altitude Mean (SD) PEFR**		**High altitude Mean (SD) PEFR**	
	Female	**Male**	**Female**	**Male**
7-9	141.87 (9.81)	149.81 (11.63)	157.50 (18.56)	169.22 (22.25)
10-12	192.45 (24.45)	204.90 (29.14)	219.79 (31.18)	233.67 (39.56)

Table 3: Mean, median and P-value of height, weight, BMI and SpO2 among the study population (n=400).

Variables	Low altitude		High altitude		P value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	
Height	133(9.62)	133 (124-142)	130.25 (10.16)	130 (121, 138)	0.008
Weight	29.51 (6.96)	29 (23-36)	28.90 (7.02)	28 (24, 35)	0.508
BMI	16.39 (1.65)	16.29 (14.92-17.83)	16.71 (1.73)	16.79 (15.60-18.08)	0.030
SpO2	98.12 (0.92)	98 (97-99)	97.25 (1.11)	97 (96-98)	<0.001

Table 4: Correlation between height, weight, SpO2, PEFR and age of the study children (n=400).

			Height	Weight	SpO2	PEFR	Age
Spearman's rho correlation	**Height**	Correlation coefficient	1	0.967	0.374	0.854	0.947
		P value	-	<0.001	<0.001	<0.001	<0.001
	Weight	Correlation coefficient	0.967	1	0.335	0.890	0.910
		P value	<0.001	-	<0.001	<0.001	<0.001
	SpO2	Correlation coefficient	0.374	0.335	1	0.164	0.330
		P value	<0.001	<0.001	-	0.001	<0.001
	PEFR	Correlation coefficient	0.854	0.890	0.164	1	0.832
		P value	<0.001	<0.001	<0.001	-	<0.001
	Age	Correlation coefficient	0.947	0.910	0.330	0.832	1
		P value	<0.001	<0.001	<0.001	<0.001	-

Table 1 shows clinical and demographical profile sample. Table 2 shows distribution of different parameters like height, weight, BMI, SpO2 and PEFR among male and female in the age group 7-9 and 10-12 years in respect of low and high altitude. Table 3 shows distribution and association of height, weight, BMI and SpO2 among the study subjects according to the altitude (SD-standard deviation, IQR- inter quartile range, * Mann Whitney U test). Mean height, BMI and SpO2 between low and high-altitude children were statistically significant (p value < 0.05). Table 4 shows (Spearman's rho correlation) age, height, weight, SpO2 and PEFR were correlated, and it was statistically significant (p value <0.05).

DISCUSSION

Children exposed to reductions in inspired oxygen levels as a result of altitude may be vulnerable to the pathological consequences of hypoxaemia. Altitude gain causes a drop in the partial pressure of inspired oxygen and thus a lower haemoglobin oxygen saturation (%SpO2) resulting in a state of hypoxia. At high altitudes, a number of acute and chronic airway mechanisms are activated, which are aimed at optimizing oxygen availability. The present study was conducted to find out the difference of peak expiratory flow rate among school children of high-altitude region of Darjeeling district and low altitude school children of both Darjeeling and Purulia district. The findings of the study are discussed with other studies done elsewhere. Rahman RS et al, found that there were no significant in the mean values of age, body mass, and height between both tested groups of both sexes indicating that both groups were homogenous. The present study observed that age and sex distribution was similar among both the group of children and the difference in the age group and the sex composition among both the groups was not statistically significant.

Sharat Gupta et al, reported similar observation of no statistically significant difference in the values of above parameters between highlanders and lowlanders, of both sexes, in any of the two age groups, indicating that both the groups were comparable, like our study, in which we found age and sex distribution was similar among both the group of children and the difference in the age group and the sex composition among both the groups was not statistically significant.[8] Kashyap et al, measured the PEFR in healthy tribal children living at high altitude in the Himalayas and found that the values are comparable with those of north Indian urban children.[9] The present study found that the correlation between Age, height, weight, SpO2 and PEFR was statistically significant. Fernandez et al, found that PEFR had significant correlation with height, weight, age, socio-economic condition, chest circumference and body surface area, like previous studies. Among which height had highly significant relation with PEFR. This finding corresponds with the present study.

Deshpande et al, observed that there was significant positive correlation between pulmonary functions with height, weight and upper segment of the body. This shows that development of pulmonary functions and growth of physical parameters goes hand in hand in children. Tahera H et al, study results show PEFR has good positive correlation with height, age and body surface area in both sexes. There isa need to have regional values for the prediction of normal spirometric parameters in a country like India with considerable diversity.[12] The present study found the mean (SD) PEFR among the low altitude children was 172.40 +/-(33.80); while among the high-altitude children the PEFR was higher, 194.10 +/-(43.28). This difference in the PEFR among the group was statistically significant. In corresponds with our study finding, Qazi et al, who detailed that elevation more noteworthy than 1500 meters seems to bring about quantifiable changes in lung volumes and flow rates.[13] Also, the higher anthropometric proportions, e.g. trunk to leg proportion (which signifies a high vertical trunk size), and low levels of environmental pollution in HA areas may explain increased values of lung volumes and flow rates in residents of these areas. However, Weitz et al, suggested that greater lung function at higher altitude primarily results from development of a hypoxic environment and is less likely to be caused by increased activity or lower pollution.[14] West et al suggested that since the air at higher altitude is less dense, airway resistance is reduced, and maximum inspiratory and expiratory flows are greater than that at sea level.[15]

A study by Puchner et al demonstrated that children from high altitude have increased lung volumes compared to children residing at normal altitude and suggested a gender difference in the response to chronic hypoxia early in life. They also found that serum levels of vascular endothelial growth factor (VEGF) and erythropoietin (EPO) were significantly higher in infants and toddlers at high altitude compared to subjects at normal altitude. These outcomes demonstrate that incessant hypoxia from living at high altitude expands hypoxia inducible development variables and lung development right on time in life. The findings in infants and toddlers are consistent with the increased lung volumes found in older children and adults at high altitude compared to that low altitude, thus indicating that the effects of chronic hypoxia upon lung growth begin very early in life.

This study was done in small sample size (n=400) within one year which may not reflect the whole districts population were the limitations of the study.

CONCLUSION

The study portrays that the mean height, BMI and SpO2 was significantly lower among high altitude children than low altitude. The mean PEFR among the low altitude children was significantly lower than the high-altitude children. There was significant correlation between age, height, weight, SpO2 and PEFR. Further research with higher study design should be undertaken to assess the changes in other lung function parameters as well as in high altitude children and adults (e.g., forced vital capacity, forced expiratory volume, maximum ventilatory volume). The present study concluded that children at high altitude have significantly higher pulmonary function compared to those at low altitude.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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