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Johri, Pooja*, Lehri, Anuradha

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Johri, Pooja,
Senior Biochemist,
Central Research Institute, Kasauli, India.
Email: johri_pooja@yahoo.com
Lehri, Anuradha
Assistant Professor, Department of Sports Sciences, Punjabi University, Patiala – 147002.
Email: anu_lehri@yahoo.co.in
Corresponding Author. Johri, Pooja,
PhD Scholar, Department Of Sports Science, Punjabi University, Patiala – 147202 Email: johri_pooja@yahoo.com

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Abstract
The present investigation is a comparative study of pulmonary function variables mainly Force Vital Capacity, Forced expiratory Volume in 1 sec and Peak Expiratory Flow rate of Male Rajput population of high and low altitude areas of Himachal Pradesh. The total subjects taken for the study were healthy 400, out of which 200 were taken from high altitude (>2200 m) and 200 were taken from low altitude (<300m). The subjects were divided into four groups of 5 years interval. The variables were measured with the help of calibrated computerized spirometer named Spiro Excel manufactured by Medicaid Systems, Chandigarh. The results indicate that there exist significantly higher values of FEV1 (forced expiration volume in 1 sec) in high altitude population of the age 20-25, 26-30 & 31-35 in comparison to corresponding age peer groups of low altitude. The Force Vital Capacity is found to be highly significantly greater in the age group of 36-40 years in comparison to rest of the age groups. The peak expiratory flow rate is found to be significant higher in the age group of 20-25, 31-35, 36-40 and not in 26-30 age group of residents of high altitude. Quite surprisingly Rajputs of 36-30 age group of low altitude have more PEFR than Rajput residents of high altitude. The results of pulmonary variables are discussed at length in the paper.

Introduction

The functional alteration associated with high altitude exposure represents one of the most thoroughly investigated area of environmental physiology. Many studies of adaptation to high altitude hypoxia have focused on the blood because of its role in oxygen transport. About 140 million persons reside at high altitudes over 2500 m, mainly in North, Central, and South America; Asia; and eastern Africa *(Ward et al., 2000; Sherpa et al., 2011)*. It has been proven beyond doubt that genetic factors guide the course to maturity and the environmental factors accelerate or retard this course. This explains to larger extent, the differences in body structure among different population groups. The important factors to affect the human morphology and physiology are extremes of environmental temperature, nutrition and altitude. There are so many parameters which differ in both the populations whether they live at high altitude or low altitude. Viault, a French physician first reported an increase in respiratory oxygenating element of blood in Europeans and Andean highlanders. Thereafter an increase in total quantity of haemoglobin was reported at high altitude by *Baker et al (1976) Monge (1978).* Obviously an increase in total quantity of haemoglobin is going to influence the pulmonary variables. People of north Indian state of Himachal Pradesh have been the subject of serological anthropological research for several decades *(Bhasin et al., 1992; Bhasin and Walter, 2001: Singh et al., 1994)* but biochemical genetics investigations focusing on the distribution of various serum protein and erythrocyte enzyme polymorphisms among them began only in early eighties of the last century *(Singh et al., 1982; Papiha et al., 1982; Chahal et al., 1982; Bhasin et al., 1983).* Besides these, some other such studies on remote populations (particularly tribals) inhabiting higher mountainous ranges in the northern districts of Kinnaur *(Papiha et al., 1984)* and Chamba *(Papiha et al., 1996)* and some on caste populations of southern districts of Shimla *(Sarin and Chahal, 2001)* and Solan *(Sarin and Chahal, 2002)* have been reported. *Bhasin et al. (1983)* has studied on caste and tribal groups of Lahaul- Spiti and Kullu districts on blood groups, serum proteins and red cell enzyme markers. However there has been no comparative study on physiological parameters. *Pruthi & Multani (2012)* reported the influence of age on lung function tests on northern Indian population. Spirometric evaluation of pulmonary function, is considered to be the most important tool for clinical assessment of respiratory functions in individuals *(Ferguson et al, 2000; Barreiro & Perillo, 2004; Madan et al, 2010)* According to *Pellegrino et al, (2005) & Budhiraja et al, (2010)* population specific reference values are essential for maintaining the reliability of pulmonary function evaluation. Till now, several studies have reported reference values for pulmonary function from different corners of the world, including India *(Vijayan et al, 2000; Maiolo et al, 2003; Van Sickle et al, 2011; Feng et al, 2011)*. There is significant difference in these values owing to genetic, environmental and ethnic differences of

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the population studied *(Chen et al, 2007; Trabelsi et al, 2007)*

However, it is extremely important to quantify the response related to various respiratory parameters so as to assess the true response of the people at high altitude. This becomes more necessary in view of the fact that the medical facilities at high altitude are often not available and when the hilly natives reach the plains; their values may be compared by mistake with those obtained from the people living in non hilly areas. The present study was therefore undertaken to assess the true respiratory parameters of the population living in certain high altitude areas and were considered healthy and normal with the following objective:

To study and compare forced expiratory volume in 1 sec (FEV_1), forced vital capacity (FVC) and peak expiratory flow rate (PEFR) among the population living in high altitude and low altitude areas.

Materials and Methods

The study was conducted on 200 Rajput males ranging in age from 20-40 years living at an altitude of more than 2400m residing at Bulah, Pataru, Sangalwada, Rail Chowk, Tunga Dhar areas of Distt. Mandi. Their sample testing was carried at the primary health center at Janjheli, situated in Distt. Mandi and 200 Rajput males ranging in age from 20-40 years living at an altitude of 392 m residing at Baddi area of Distt. Solan of Himachal Pradesh. The subjects were divided into four age groups of 5 yearly interval. Each interval had 50 subjects .

AGE GROUP	No. of subjects
20-25	50
26-30	50
31-35	50
36-40	50

Instrument used:

Computerized Spirometer: Pulmonary function testing (PFT) was done using a computerized spirometer named Spiro Excel manufactured by Medicaid Systems, Chandigarh. Spiro Excel is an instrument designed for lung function screening. The core of the system is the 'intelligent' flow meter that can be connected to any laptop or desktop through the USB cable. Spiro Excel gives accurate results without manual calculation according to standardized testing protocol and predictions as outlined by *American Thoracic Society, (1995).* FVC, FEV_1 and PEFR were measured with the spirometer.

Measurement of Pulmonary Functions:

The experimental protocol was explained to all the subjects. Each subject was explained and demonstrated about the procedure to be performed. Each subject was allowed to do enough practice, as lung volume depends on the subject's making a maximal voluntary effort. Full series of test took 4 to 5 minutes on each subject.

Pulmonary function testing was performed using the acceptability standards outlined by the *American Thoracic Society, (1995)* with subjects in a standing position and wearing nose clips. Subjects were educated prior to PFT measurements regarding the PFT

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performance. The parameters of PFT studied, included Forced Vital Capacity (FVC), Forced Expiratory Volume in first second (FEV_1), and Peak Expiratory Flow Rate (PEFR). The respiratory maneuvers were demonstrated to each subject before the test. Three reproducible tests were carried out for each measurement & the best result was selected for statistical analysis. For FVC and FEV_1, the subjects were instructed to breathe in fully by deep inspiration with their nostrils closed, to seal their lips around the sterile mouthpiece of the spirometer and to forcefully expire the air. The subjects breathed in as deeply as possible and then blew out as hard and fast as possible to estimate the PEFR. Each individual made three attempts and the largest values for each parameter were used as recommended by the *ATS, (1995).*

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Table -1: Comparison of statistical constants of high & Low altitude groups

Age (years)	Age (years) High Altitude	Low Altitude	P value
20-25	22.37±1.2	22.48±1.6	0.693
26-30	27.70±1.3	27.24±1.5	0.103
31-35	32.44±1.1	32.50±1.3	0.809
36-40	36.97±1.3	37.16±1.3	0.463
Total	29.87±5.6	29.85±5.7	0.965

Mean FEV_1 (Table-2) in the age group 20-25, in high altitude is 4.15 ± 0.45 and in the low altitude the mean FEV_1 comes out to be 3.63 ± 0.53, p value is highly significant (less than 0.05). FEV_1 comparison between the two groups among the age group 26-30 years reveal

Spirometer

Results:

The mean, SD and Pearson Coefficient of correlation was calculated by SPSS software. Comparison of the age in years of different age groups among high and low altitude groups (Table-1), reveal p value that is non- significant. There is no significant difference in mean and standard deviation among the groups highly significant (0.020) difference between the groups with high altitude group possessing significantly greater FEV_1 value than the low attitude group. Mean FEV_1 comparison in the age group 31-35 of high altitude demonstrate mean value of 4.76 ± 0.58 as compared to the 3.51 ± 0.50 observed in the low altitude group, p value again demonstrate highly significant (0.020) difference. However similar FEV_1 comparison in the age group of 36-40 years between the high altitude and low altitude groups reveal FEV_1 Mean±SD (3.95±0.81) as compared to the low altitude group having Mean±SD (3.68±0.44), p value is again highly significant (0.040).

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Table -2: Statistical comparison of FEV_1 between the high and low altitude groups among various age groups

Age group (years)	FEV1		
	High Altitude	Low Altitude	P value
20-25	4.15 ± 0.45	3.63 ± 0.53	0.010
26-30	4.29 ± 0.67	3.67 ±0.63	0.020
31-35	4.76 ± 0.58	3.51 ± 0.50	0.010
36-40	3.95 ±0.81	3.68 ± 0.44	0.042
Total	4.29 ± 0.70	3.63 ± 0.53	0.020

Comparison of mean values of Forced vital capacity are observed to differ non significantly in all the age groups except when comparison is done between the high and low altitude groups belonging to the age groups 31-35, and 36-40 age groups (Table-3). Mean FVC in the age group 20-25 of high altitude is 4.27±0.71 and as compared to 4.19± 0.58 observed in the low altitude group, p value is not significant.

Table -3: Statistical comparison of FVC between the high and low altitude groups among various age groups

Age group (years)	FVC		
	High Altitude	Low Altitude	P value
20-25	4.27 ± 0.71	4.19 ± 0.58	0.528
26-30	2.84 ±0.33	2.96 ±0.55	0.202
31-35	3.01 ± 0.40	2.80 ±0.53	0.028
36-40	2.45 ±0.57	2.98 ±0.46	0.010
Total	3.14 ± 0.86	3.23 ± 0.77	0.281

Peak expiratory flow rate demonstrates highly significant differences among the high and low altitude groups in all the age groups except 26-30 age group (Table -4). In general high altitude residents belonging to the age groups 20-25, 31-35 & 36-40 years possess significantly greater PEFR vaues as compared to thir low altititude age group peers. If PEFR is compared in the age group 26-30 of high altitude it comes out to be 441.13 ±44.16 and in low altitude it comes out to be 428.66± 60.85, p value is not significant.

Table 4: Statistical comparison of PEFR between the high and low altitude groups among various age groups

Age group (years)	PEFR		
	High Altitude	Low Altitude	P value
20-25	436.93±64.92	373.07±47.20	0.010
26-30	441.13±44.16	428.66±60.85	0.246
31-35	453.90±47.07	420.47±38.50	0.020
36-40	395.55±46.83	429.45±28.82	0.030
Total	431.88±55.54	412.83±50.66	0.020

Discussion:

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The present study aimed at establishing the effect of altitude on FEV_1, FVC and PEFR values of healthy high lander and low lander men. In our study, significantly higher FVC, PEFR values were observed in high-altitude native men as compared to their lowlander counterparts. Many other authors throughout the world have also reported results similar to those of the present study [*Malik et. al (1979); Malik et. al (1993); Havryk et. al (2002), and Wood et. al (2003)]*.

Qazi et al. (2003) reported that altitude greater than 1500 meters appears to cause measurable changes in lung volumes and flow rates; this is because the accessory muscles of respiration are far more developed in higher-altitude residents due to hypoxia. Also, the higher anthropometric ratios, e.g. chest to leg ratio (which denotes a high vertical chest size) and better lung growth due to increased physical activity, lesser population density, and low levels of environmental pollution in high-altitude areas may explain increased values of lung volumes and flow rates in residents of these areas. However, *Weitz et al.(2002)* 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. *West (2012)* 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. From the above data obtained during our study we can conclude that Peak expiratory flow rate is high and good in people residing at high altitude in comparison to the people living in low altitudes. In terms of forced vital capacity the persons belonging to age group 31-35 and 36-40 of high altitude have better adaptation than the persons of the same age group living in low altitude. Forced expiratory volume in 1 sec is significantly higher in residents of high altitude as compared to residents of low altitude. The above results suggest that altitude do play an important role in determining the size of the lungs, other factors like hypoxia & low ambient pressure at altitude may also contribute to the overall pattern of lung function tests in high landers. The Vital capacity of the Peruvians & Bhutanese also have much higher values than their counterparts at sea level as reported by *Wool Cock et al (1972).*

Conclusion: Altitude do play a significant role in assessing the pulmonary function variables and the present study suggest that people residing at high altitude have better better FVC, FEV_1 and PEFR than the men residing at low attitude.

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Conflict of Interest None Declared