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EFFECT OF ALTITUDE ON SPIROMETRIC VALUES

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ABSTRACT:

A total of 132 healthy male subjects from Haripur, Abbottabad and Nathiagali were tested for their lung volumes and flow rates. The spirometric values from Haripur and Abbottabad are comparable to other studies carried out in Pakistan. It was found that there were no significant differences in FEV_1 and $FEV_1/FVC\%$ of the subjects but the FVC of the subjects from Nathiagali was found to be significantly higher than the lowlanders. Moreover the rate of decline in the lung volumes and especially the flow rates of the subjects from Nathiagali was higher than the lowlanders. Further insight in the problem is suggested.

INTRODUCTION:

Spirometry is a simple non-invasive procedure proved valuable in both diagnosis and prognosis of pulmonary diseases, in clinical practice and occupational medicine[1]. Before one can test the state of lung function in a subject, it is essential that there should be a standard of '*Norms*' against which the observed values can be compared and the decision of normality or otherwise can be made. In the outpatient clinics the most convenient to use spirometric parameters are the measurement of FVC and FEV_1. The present work was carried out to establish the spirometric reference values for the hilly areas of Hazara Division, which are not available so far.

MATERIAL AND METHOD

A total of 132 male subjects were studied from the areas of Haripur, altitude 530m. ASL (n=45, group A), Abbottabad, altitude 1,235 m. ASL (n=42, group B) and Nathiagali, altitude 2,535 m. ASL (n=45, group C). All subjects were born in and were permanent residents of the test areas with a continuous stay in the area for at least 6 months preceding the test. The age range of the subjects was between 21 and 40 years on the next birthday and none had ever smoked tobacco. Only those subjects were included in the study who were clinically fit having no present or past respiratory disease, congenital anomalies or thoracic surgery, or any other disease known to influence the respiratory function.

The height of the subjects was recorded in centimetres (Cm.), weight in kilograms (Kg.) and surface area was calculated in m^2. The chest measurements were taken at nipples at Functional Residual Capacity (FRC) and Total Lung Capacity (TLC) in Cm. And difference was calculated as the expansion of the chest.

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A waterless wedge type spirometer (Vitalograph® H-Model) was used for spirometry and the values were corrected to BTPS. At least 3 acceptable[2] forced expiratory spirograms were recorded from every subject and the one with highest sum of Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1st Second (FEV_1) was taken as the final spirogram[3-5]. The spirograms were analysed for Vital Capacity (VC), Forced Vital Capacity (FVC), FEV_1 and Forced Expiratory Ratio (FEV_1/FVC%). The data were subjected to Mean and Standard Deviation, Student's *t*-test and Multiple and Linear Regression.

RESULTS

The subjects from each area were further categorised into age group 21 to 30 years (subgroup a) and 31 to 40 years (subgroup b). Tables 1, 2 and 3 show the anthropometric measurements of the subjects. The mean spirometric values were calculated between the subjects at different altitudes and between the younger and older age groups at the same altitude. The results are shown in Table 4.

Table 1. Anthropometric measurements of the subjects. Mean ± (SD)

Parameter	Group A	Group B	Group C
Age (Year)	29.49 (5.3)	29.74 (5.5)	29.76 (6.7)
Height (Cm.)	171.40 (4.9)	171.17 (4.3)	172.67 (5.4)
Weight (Kg)	64.00 (9.2)	64.86 (6.6)	59.33 (5.8)

Table 2. Chest circumferences of the subjects in Cm. Mean ± (SD)

Group	At FRC	At TLC	Expansion
A	88.13 (5.9)	93.16 (5.9)	5.24 (1.5)
B	86.48 (5.5)	94.10 (4.9)	7.56 (1.8)
C	82.64 (4.7)	92.42 (4.9)	9.77 (2.2)

Table 3. Spirometric values of the subject. Mean ± (SD)

Parameter	Group A	Group B	Group C
VC (L)	4.303 (0.6)	4.489 (0.6)	4.595 (0.4)
FVC (L)	4.441 (0.7)	4.605 (0.6)	4.724 (0.4)
FEV_1 (L)	3.716 (0.6)	3.854 (0.5)	3.927 (0.5)
FEV_1/FVC% (L)	83.53 (5.9)	83.91 (5.2)	82.90 (6.3)

Student's *t*-test was applied to see any differences in means and multiple regression equations were derived between age, height and various test parameters. The results are shown in Table 5.

DISCUSSION

A reduction in the barometric pressure decreases the density of air and hence the resistance to air flow. This allows additional expansion of the chest for a given muscular power. Excessive physical activity demands increased ventilation to fulfil the additional O_2 requirements[6]. The chest expansion is found to be more in the natives of Nathiagali compared to lowlanders (Table 2) and more in rural than urban

Table-4: Comparison of spirometric values between younger & older age groups. Mean ± (SD)

Subgroup a: Age 21 to 30 year, Subgroup b: Age 31 to 40 year

Parameter	Group A		Group B		Group C	
	a	b	a	b	a	b
VC (L)	4.358 (0.742)	4.248 (0.513)	4.711 (0.557)	4.244 (0.503)	4.689 (0.410)	4.489 (0.396)
FVC (L)	4.523 (0.750)	4.355 (0.511)	4.825 (0.602)	4.362 (0.452)	4.824 (0.400)	4.609 (0.394)
FEV_1 (L)	3.874 (0.673)	3.551 (0.548)	4.015 (0.559)	3.677 (0.459)	4.150 (0.382)	3.672 (0.417)
FEV_1/FVC %	85.72 (5.692)	81.24 (5.536)	83.64 (5.913)	84.20 (4.493)	86.11 (5.553)	79.23 (5.268)

Table 5. Student's *t*-test results for mean differences of various tests between groups.

All values in their respective units. NS=Non-significant

Parameter	Comparison groups	Mean Difference	*t*-values	*p*
VC	A vs B	0.185	-1.382	NS
	A vs C	0.291	-2.523	<0.05
	B vs C	0.106	-0.981	NS
FVC	A vs B	0.164	-1.217	NS
	A vs C	0.283	-2.420	<0.05
	B vs C	0.119	-1.076	NS
FEV_1	A vs B	0.138	-0.907	NS
	A vs C	0.211	-1.691	NS
	B vs C	0.138	-0.744	NS
FEV_1/FVC%	A vs B	0.380	-0.316	NS
	A vs C	0.630	0.482	NS
	B vs C	-1.010	0.806	NS

populations[7]. Not only the altitude of dwelling but the level of physical activity since childhood and genetic factors also determine the size of the lungs. Together all these factors favour speedy growth of lungs to attain the adult size at an early age and to a higher maximal size at high altitude[8-10].

The observed VC of group A is consistent with the earlier studies in Pakistan[5, 11-14] and to North Indian subjects[15] due to similar racial and ethnic groups in these studies. The VC of group C is more than other Pakistani populations but slightly less than the

European populations except the people of Denmark[16]. This increase in VC and FVC is reflected by the extent of chest expansion in the subjects (Table 2) which is 5.24 Cm. In subjects from Haripur, 7.55 Cm. In subjects from Abbottabad and 9.77 Cm. In subjects from Nathiagali.

The differences in the spirometric values is significant ($p<0.05$) in volumes (FVC) and not in the flow rates (FEV_1, $FEV_1/FVC\%$). This is in conformity with Sliman, 1984.

Both FVC and FEV_1 are more reproducible and therefore particularly suited for a cross-sectional screening of a community[17] but both FVC and FEV_1 are relatively insensitive to detect early airway obstruction when only the peripheral airways are affected[2]. FEV_1 is decreased both in restrictive and obstructive diseases. The decrease in the former is due to a decrease in the total lung capacity and in the latter it is due to increased airway resistance. The two conditions can be differentiated by the $FEV_1/FVC\%$, which will be normal or even increased in restriction and will be less than normal in obstruction[18-19]).

A look at Table 5 reveals that the rate of fall in the spirometric values, especially in the FEV_1 and $FEV_1/FVC\%$ in group C from younger to older subgroups is higher than the groups A and B. The reason for a rapid fall in spirometric values in Nathiagali population may be due to exposure to excessive pollens and living in closed unventilated rooms where mainly wood is used for fire in the long winter season. This needs further insight in the problem in view of the community health in that area.

REFERENCES

1. Prieto, F., English, M.J., Cochrane, G.M., Clark, T.J.H., and Rigden, B.G. (1978). Spirometry in healthy men: a correlation with smoking and with mild symptoms. *Thorax*, 33: 322-7.
2. Committee Recommendations (1975). The assessment of Ventilatory Capacity. Statement of the Committee on Environmental Health and Respiratory Physiology, American College of Chest Physicians. *Chest*, 67: 95-7.
3. Knudson, R.J., Lebowitz, M.D., Holberg, C.J., and Burrows, B. (1983). Changes in the Normal Maximal Expiratory Flow-Volume Curve with Growth and Aging. *Am. Rev. Respir. Dis.*, 127: 725-34.
4. Leech, J.A., Ghezzo, H., Stevens, D., and Becklake, M.R., (1983). Respiratory Pressures and Functions in Young Adults. *Am. Rev. Respir. Dis.*, 128: 17-23.
5. Ayub, M., Zaidi, S.H., and Burki, N.K. (1987). Spirometry and flow-volume curves in healthy normal Pakistanis. *Br. J. Dis. Chest*, 81: 35-45.
6. Kryger, M. (1980). Breathing at High Altitude: Lessons Learned and Application to Hypoxemia at Sea Level. *Adv. Cardiol.*, 27: 11-6.
7. Miller, G.J., Saunders, M.J., Gilson, R.J.C., and Ashcroft, F.T. (1977). Lung function of healthy boys and girls in Jamica in relation to ethnic composition, test exercise performance and habitual physical activity. *Thorax*, 32: 486-96.
8. Lawther, P.J., Brooks, A.G.F., and Waller, R.E. (1978). Respiratory function measurements in a cohort of medical students: a ten-year follow-up. *Thorax*, 33: 773-8.
9. Schoenberg, J.B., Beck, G.J., and Bouhuys, A. (1978). Growth and decay of Pulmonary Function in healthy blacks and whites. *Respiratory Physiology*, 33: 367-93.
10. Sliman, N.A. (1984). The Effect of Altitude on Normal Pulmonary Function Tests: A Comparison Between the Dead Sea Area and Amman. *Aviat. Space and Environ. Med.*, 55: 1010-4.
11. Malik, M.A., Moss, E., and Lee, W.R. (1972). Prediction values for the ventilatory capacity in male West Pakistani workers in the United Kingdom. *Thorax*, 27: 611-9.
12. Williams, D.E., Miller, R.D., and Taylor, W.F. (1978). Pulmonary function studies in healthy Pakistani adults. *Thorax*, 33: 243-9.
13. Rafi, F., and Bano, M., (1982). Pulmonary Function Tests in the Normal Pakistani Population. *JPMA*, 32(1): 9-13.
14. Younas, A., Ahmed, Q.R., Hussain, M., and Rashid, A. (1986). Comparison of spirometric variables between heavy cigarettes smokers and nonsmokers. *RMJ*, XV(III & IV): 21-4.

15. Jain, S.K., and Ramiah, T.J. (1969). Normal standards of pulmonary function tests for healthy Indian men 15-40 years old: Comparison of different regression equations (Predicted formulae). *Ind. J. Med. Res.*, 57(8): 1453-66.
16. Oxhój, H., Jeppesen. G.M., Larsen, V.H., and Jórgensen, B., (1988). Spirometry in healthy adult never-smokers. *Clinical Physiology*, 8: 329-39.
17. Cochrane, G.M., Prieto, F.. and Clark, T.J.H. (1977). Intrasubject variability of maximal expiratory flow volume curve. *Thorax*, 32: 171-6.
18. West, J.B. (1980). Respiratory Physiology in Unusual Environment. *In Respiratory Physiology, the essentials*. 2nd Ed. pp 128-30. Williams and Wilkins Company, Baltimore.
19. Burki, N.K. (1982). Pulmonary Function Tests. *In Pulmonary Diseases*, 1st Ed. pp 33-68. Medical Examination Publishing C. Inc., an excerpta Medical Company, Garden City New York, U.S.A.