Effects of sudden exposure to high altitude on Pulmonary functions

Pages with reference to book, From 175 To 178

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Abstract

To assess the changes in pulmonary functions in terms of respiratory frequency (f), tidal volume (VT), forced vital capacity (FVC), forced expiratory volume for first second (FEV1, maximum ventilatory volume (MVV) and peak expiratory flow rate (PEFR), on sudden exposure to high altitude, 16 healthy normal, non-smokers, lowland subjects (11 medical cadets mean age 20.18±1.44 yr and 5 jawans mean age 32.2±3.54 yr) were studied at low altitude (518 m) and on the first 3days at high altitude (4570 m). On exposure to high altitude significant decrease in VT ($P< 0.05$) FVC ($P <0.01$), FEV1($P < 0.05$), FEV, /FVC ($P <0.05$), MW ($P <0.05$) and PEFR ($P <0.05$) was observed. It was primarily due to significant increase in respiratory frequency (f: control mean 15.2±2.82 to 23.4±2.1 breaths per min $P <0.05$) on day 1. All these parameters came close to the mean value on day 3. Systemic effects of hypoxia associated with high altitude exposure were variable among the subjects but the relatively younger group of subjects showed better and quick acclimatization. (JPMA 35 : 175, 1985).

Introduction

Spaniards were the first to notice that the high altitude environment could have adverse effects on the normal functioning of people accustomed to living at low altitude.[1] Effects of sudden exposure to high altitude have been described as acute mountain sickness consisting of headache, lassitude, insomnia, nausea, GIT disturbances, shortness of breath and urinary discomfort[2]. Although the symptoms and severity vary in different persons but the effects are more profound on the type of exposure and on physical built of the subject[3]. Exposure to high altitude results in an increase in resting ventilation and a decrease in vital capacity has been known for over seven decades[4]. Recent studies have indicated that useful information can be derived from the change in pulmonary functions from low land on sudden exposure to high altitude.[5]

The present study was undertaken to examine the changes in pulmonary functions and acclimatization period in healthy normal subjects during relatively acute exposure to high altitude.

Material and Methods

Eleven young medical cadets (mean age 20.18 ± 1.44 yr) and five jawans (mean age 32.2±3.54 yr) were studied. All the subjects were low landers, non-smokers and free from any cardiopulmonary and allergic disorders. During selection of the subjects they were informed of the study, effects of high altitude and then a written consent was obtained from each subject.

Subjects were instructed during orientation on the use of a hand held Digital Pulmometer (Kinetic) and a mini Wright's Portable Peak Flowmeter to measure VT, FVC, FEV_1, MVV and PEFR - techniques have been described in detail in previous study.[6] Measurements were made for each subject on 2 consecutive days at low altitude (Rawalpindi 518 m, atm. pressure 735 mm Hg). The ambient temperature at low altitude ranged from 22°C to 28°C. All subjects were in sitting position breathing through the mouth piece with a noseclip in place. The subjects were then transferred by road to high

altitude (Khunjrab Top 4570 m, atm. Pressure 405 mm Hg) over a period of 48 hours. The ambient temperature at high altitude at the time of study ranged between 8°C and 16°C. Three measurements were averaged at each occasion. All the subjects were appropriately dressed and comfortable during the study. Studies were performed on 3 consecutive days at high altitude, during their sojourn at high altitude the subjects did not undertake any strenuous exercise and remained throughout at the same altitude (with in ± 20m). The subjects returned to low altitude on the 5th day. The studies were repeated on 2 consecutive days after 2 days complete rest.

The data was subjected to standard statistical analysis and comparison of high and low altitude data was made by using Student's "t" test. The results for cadets and jawans were also analysed for significant variance.

Results

Major adverse effects of acute mountain sickness were observed on sudden exposure to high altitude in this group of subjects. Majority of the subjects had sever-c headache, nausea, vomiting, breathlessness and dizziness. These symptoms were more profound among the jawans and physically weakly built persons as compared to the young and better nourished medical cadets (Table 1).

Table I

Age, Height, Weight and Chest Measurements.

Variable	Cadets (n = 11)	Jawans (n = 5)	P
Age in year	20.18±1.44	32.2±4.54	<0.01
Height in cm	172.9±4.32	175.6±3.84	<0.05
Weight in Kg	64.1±3.8	67.2±5.8	< 0.05
Chest in cm (normal)	85.2±3.12	92.8±4.2	<0.01
Fully expanded	89.8±4.52	96.2±5.4	<0.01

Difference also occurred in mood symptoms (satisfaction, happiness), tired symptoms (drowsy, sleepy) and arousal level symptoms (refreshed, vigorous, energetic). Again the younger group of subjects resolved spontaneously within 48 hr but the jawans resolved by symptomatic treatment. Two subjects did not come out of this acute mountain sickness but rather deteriorated and thus were evacuated back. The low altitude values for the various parameters measured on 2 consecutive days before and on 2 consecutive days after exposure to high altitude were not significantly different ($P > 0.05$) in any subject and are therefore combined and treated as control values.

Table II

Pulmonary Functions and Heart Rate In Cadets (n=11)

Variable	Low altitude (518 m)			High altitude (4570 m)			
			Day 1		Day 2		Day 3
			P		P		P
Heart rate/min	82.3±5.7	98.8±7.5	<0.01	102.4±6.2	<0.05	90.4±7.2	<0.05
Respiratory rate/min	15.2±2.8	23.4±2.1	<0.05	25.2±4.3	<0.05	21.8±3.6	<0.05
V_T	0.72±0.24L	0.68±0.16L	<0.05	0.70±0.25L	<0.01	0.74±0.12L	NS
FVC	4.32±0.38L	3.76±0.32L	<0.01	3.98±0.48L	<0.05	4.26±0.24L	NS
FEV_1	3.26b0.18L	2.84±0.48L	<0.01	3.04±0.36L	<0.01	3.28±0.48L	NS
FEV_1/FVC	0.79	0.75	<0.05	0.76	<0.05	0.76	<0.05
MVV	54.8±4.18L	47.28±5.2L	<0.05	53.8±5.24L	NS	56.4±3.28L	NS
PEFR	498.2±60.2 L/min	432.6±54.4 L/min	<0.05	448.4±39.2 L/min	<0.05	512.0±32.5 L/min	<0.01

Table III

Pulmonary Functions and Heart Rate In Jawans (n = 5).

Variable	Low altitude (518 m)			High altitude (4570 m)			
			Day 1		Day 2		Day 3
			P		P		P
Heart rate/min	84.6±4.3	94.2±8.4	<0.01	94.5±5.4	<0.01	86.7±8.2	NS
Respiratory rate/min	16.8±2.3	22.8±3.8	<0.05	22.2±5.2	<0.05	18.4±4.6	<0.01
V_T	0.74±0.32L	0.65±0.22L	<0.05	0.69±4.44L	<0.05	0.75±0.40L	NS
FVC	4.48±0.38L	3.82±0.32L	<0.01	4.14±0.22L	<0.01	4.22±0.38L	<0.01
FEV_1	3.39±0.28L	2.71±54L	<0.01	3.10±0.34L	<0.01	3.12±0.26L	<0.01
FEV_1/FVC	0.76	0.71	<0.05	0.73	<0.05	0.74	<0.01
MVV	53.8±3.48L	49.2±4.52L	<0.05	62.72±3.92L	NS	56.2±2.28L	<0.01
PEFR	512.4±52.4 L/min	472.4±48.2L L/min	<0.05	488.5±64.8L L/min	<0.01	504.8±48.4L L/min	<0.01

Tables II & III show the values of the various parameters at low and high altitude for medical cadets and jawans while table N denotes the comparison of these parameters in both groups at low and high altitude.

It is observed that sudden exposure to high altitude in low landers brings about the following changes in pulmonary functions:

a. Significant rise in respiratory frequency (f) both in cadets (P<0.05) and in jawans (P < 0.05). Tables II and III.

b. Significant decrease in pulmonary parameters in both the groups on day 1 at high altitude i.e; VT (P

<0.05), FVC (P <0.01). FEy_1 (P< 0.01), MVV (P < 0.05) and PEFR (P< 0.05). Tables II and III.

c. The younger age group subjects showed quick and better acclimatization. Table IV.

Table IV

Comparison of Pulmonary Functions For Young Cadets And Middle Aged Jawans At Low And High Altitude.

Variable	Low altitude (518 m)			High altitude (4570 m) Day 1			Day 3		
	Cadets	Jawans	P	Cadets	Jawans	P	Cadets	Jawans	P
Heart rate/min	82.3±5.7	84.6±4.3	NS	98.8±7.5	94.2±8.2	<0.01	90.4±7.2	86.7±8.2	<0.05
Respiratory rate/min	15.2±2.8	16.8±2.3	NS	23.4±2.1	22.8±3.8	<0.01	21.8±3.6	18.4±4.6	<0.05
V_T	0.72±0.24L	0.74±0.32L	NS	0.68±0.016L	0.65±0.22L	<0.05	0.74±0.12L	0.75±0.40L	NS
FVC	4.32±0.38L	4.48±0.38L	<0.01	3.76±0.32L	3.82±0.32L	<0.01	4.26±0.24L	4.22±0.38L	NS
FEV_1	3.26±0.18L	3.39±0.28L	<0.01	2.84±0.48L	2.71±0.54L	<0.01	3.28±0.48L	3.12±0.26L	<0.01
FEV_1/FVC	0.79	0.76	<0.05	0.75	0.71	<0.05	0.76	0.74	<0.01
MVV	54.8±4.18L	53.8±3.48L	NS	47.28±5.2L	49.2±4.52L	<0.05	56.4±3.28L	54.2±2.28L	NS
PEFR	498.2±60.2 L/min	512.4±52.4 L/min	<0.05	432.6±54.4 L/min	472.4±48.2 L/min	<0.05	512.0±32.5 L/min	504.8±48.4 L/min	<0.01

Discussion

The adaption to high altitude hypoxia depends mainly upon the partial pressure of oxygen in the atmosphere which decreases with an increase in altitude. High altitude hypoxia results in the increase in ventilation and has been recognised for nearly a century[7]. The present study indicates that this increase in respiratory frequency (f, control mean 15.2± 2.8 to 23.4 ±2.1 breaths/ min on day 1, P <0.05) on exposure to high altitude is associated with significant decrease in V , FVC, FEV_1, MW and PEFR (Tables II and iib. The increase in f was due to decrease in both inspiratory time (Ti) and expiratory time (TE), but TI/TE increased.[5] The change in breath timing is most likely due to stimulation of either peripheral or central chemoreceptors.[8]

The initial symptoms of high altitude sickness i.e., shortness of breath, nausea, vomiting, physical and mental fatigue, interrupted sleep and severe headache were more marked among the jawans and the individuals who lacked the ability to become acclimatized. These are the individuals who are likely to develop chronic mountain sickness and high altitude pulmonary edema "HAPE".[9] HAPE is more likely to occur if the person engages in heavy physical effort after arrival at high altitude and persons with a history of previous attacks are likely to have recurrent episodes during reascent.[10]. This necessitates that the individuals who do not acclimatize and whose pulmonary parameters remain at low ebb are not suitable subjects to be deployed at high altitude.

Tables II and III also show that all the pulmonary parameters on exposure to high altitude on 3rd day came close to the low land pulmonary parameters. This further suggests that as the subjects get acclimatized to high altitude their pulmonary functions almost return to the normal levels. Thus the pulmonary parameters have direct relationship with the acclimatization. This correlates with the finding of Husson and Otis[11].

High altitude hypoxia affects the major physiological and functional processes not only during growth but also during ageing because ageing in general results in decreased capacity of oxygen transport and functional processes during ageing may be expected to be affected at high altitude to a greater extent,

thus the elder group of people take longer time to acclimatize and their pulmonary functions remain decreased for longer period of time[12]. This is in harmony with our findings (Table W).

In conclusion the present study has shown that normal subjects living at low altitude increase their ventilation on exposure to high altitude but there is a decrease in VT FVC, FEV1, MVV and PEFR for first few days. These parameters come close to the low land pulmonary parameters as the subjects are acclimatized. Acclimatization period is short for younger age groups than the aged Ones. Further studies in this regard with longer duration will elucidate the pattern of pulmonary response to acclimatization.

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