- Changes In Vital Signs Of Lowlanders - A Study Of Four High-Altitude Himalayan Treks

Dr. Urvish Joshi*, Dr. Aparajita Shukla, Dr. Viren Kariya*****

*Asst. Professor, Dept of Community Medicine, AMC MET Medical College, **Professor, Dept of Community Medicine, Smt NHL Municipal Medical College, Ahmedabad. ***Associate Professor, Department of anatomy, PDU Medical College, Rajkot, Gujarat.

Abstract: Introduction: Not enough significant studies have been carried out so far related to changes in vital signs of high altitude trekkers in India despite having largest number of cases of high altitude illnesses. We have to depend upon the work done by western countries. So, present study is carried out to analyse the change in vital signs of high altitude trekkers particularly coming from low-lands. For that secondary data of an agency (with their official permission) are used and analysed. Material & Method: A cross-sectional study where secondary data of total 460 trekkers from four different HA treks of Himalayas [Har Ki Dun (n=21), Deoriatal Chandrasheela (n=373), Kuari Pass (n=25), Kedarkantha (n=41)] in the year 2016 were used. Their various parameters like BMI, systolic and diastolic blood pressure, SpO_2 and pulse were retrived, compared and analysed. Results: Difference between these physiological variables amongst all trekkers was calculated. Difference was statistically highly significant for variation in systolic blood pressure, SpO_2 and Pulse while it was not significant for diastolic blood pressure. Conlcusion: 40% study subjects did not have favourable BMI. Physiological variables show significant changes at high altitudes, especially systolic BP, SPO2 and Pulse. [Joshi U Natl J Integr Res Med, 2019; 10(4):73-77]

Key Words: High altitude treks, BMI, Systolic blood pressure, Diastolic blood pressure, SpO_2, Vital signs.

Author for correspondence: Dr. Viren Kariya, Associate Professor, Department of anatomy, PDU Medical College, Rajkot, Gujarat Email: vbkvbk79@gmail.com. M: 9228217389

Introduction: It is a sad anomaly that despite having the largest number of residents at high altitude (HA) and the largest number of cases of HA illnesses, we still depend to a great extent on the authoritative work done in the West. Most of this work on the physiology and pathology at HA has been based on small numbers of sojourners to HA or volunteers exposed to simulated conditions for short periods.

In the past there have been a few important contributions by service medical officers in India. The main stumbling block has been the absence of a permanent research establishment at HA. In order to correct this, the High-Altitude Medical Research Centre (HAMRC) located within 153 GH in the Western Himalaya at an altitude of 3300m was set up in 1990, by the Defence Research and Development Organisation and the DGAFMS.[1]

It is not certain whether this research centre is still functional! We are not able to find recent data and information of health-related issues of trekkers. An agency had been kind enough to share their data of various HA treks with us. Present study was carried out to understand the physiological changes in lowlanders in various HA treks.

Material and Methods: Study design and sampling: Present study is a cross-sectional study where secondary data of total 460 trekkers from four different HA treks of Himalayas [Har Ki Dun (n=21), Deoriatal Chandrasheela (n=373), Kuari Pass (n=25), Kedarkantha (n=41)] in the year 2016 were used.

Every trek has more than one campsite. Height and weight of each trekker were measured before beginning of the trek. Physiological variables like systolic Blood Pressure, diastolic Blood Pressure, peripheral capillary oxygen saturation, an estimate of the amount of oxygen in the blood (SpO2), Pulse, etc. were recorded at the arrival of each campsite.

Study tool: Pre-designed health cards were used to fill up the observations. Standardized mercury sphygmomanometer (Diamond) of same batch were used to measure BP. Similarly, oximeter readings were taken using standardized oxywatch pulse-oximeter of same batch.

Inclusion criteria : All trekkers regardless of age or gender were included in the study. Also, trekkers who could not finish the whole trek and returned from midway were also to be included. Incidentally, there was none reported.

Exclusion criteria : Trekker with place of origin from mountains or highland was to be excluded. Amongst all study Participants, there was none such. Variables: Blood pressure, SpO_2, pulse, BMI

Analysis: Health cards were translated into MS Excel and necessary analysis was done using

appropriate statistical tests. Mean, SD, one-way ANOVA were computed.

Results: Highest number of study Participants (68.3%) was between 20 to 30 years of age group followed by 30 to 40 years age group (20.7%). Mean age of study Participants was 28 ± 7.5 years. [Table 1]. Majority of the Participants were males (65.2%). [Table 2]

Table 1 – Distribution of all study Participants according to age

Age groups	No.	%
<10 years	3	0.7%
10 to 20	11	2.4%
20 to 30	314	68.3%
30 to 40	95	20.7%
40 to 50	29	6.3%
> 50 years	8	1.7%
Total	460	100.0%

Table 2 – Distribution of all study Participants according to gender

Gender	No.	%
Male	300	65.2%
Female	160	34.8%
Total	460	100.0%

Mean height and weight of study Participants across all treks were 1.7 ± 0.2 meters and 69.2 ± 13.7 kg respectively. Average BMI of all study Participants across all treks was 24.3 ± 4.4 kg/m^2. For Kedarkantha trek, mean weight was slightly higher (73.8 ± 11.3 kg) and so was BMI (25.6 ± 3.8kg/m^2). Of the total 460 trekkers under study, 175 (38%) were in the category overweight/ obese (BMI > 24.9 kg/m^2). More than half of the study Participants fell into normal weight category of BMI while 5.4% were underweight. [Table 3, 4]

Table 3 – Distribution of all study Participants according to BMI

BMI (kg/m^2)	BMI Classification	No.	%
< 18.5	Underweight	25	5.4%
18.5–24.9	Normal weight	260	56.5%
25.0–29.9	Overweight	145	31.5%
30.0–34.9	Class I obesity	26	5.7%
35.0–39.9	Class II obesity	2	0.4%
≥ 40.0	Class III obesity	2	0.4%
Total		460	100.0%

Data record of four different Himalayan treks was taken into account. Average height of each trek based on various campsites was calculated.

Table 4 – Trek-wise distribution of study Participants according to Age, Height, Weight and BMI

Trek name	Age (yrs)	Male	Female	Ht. (m)	Wt. (kg)	BMI (kg/m2)
Har Ki Dun (n=21)	29 ± 9.9	13	8	1.7 ± 0.1	69.3 ± 11.8	24.3 ± 2.9
DeoriatalChandrasheela (n=373)	27.8 ± 7	246	127	1.7 ± 0.2	68.7 ± 13.5	24.1 ± 4.2
Kuari Pass (n=25)	30 ± 9.9	12	13	1.7 ± 0.1	69.2 ± 20.6	24.5 ± 8.3
Kedarkantha (n=41)	28.2 ± 8.5	29	12	1.7 ± 0.1	73.8 ± 11.3	25.6 ± 3.8
Total (n=460)	28 ± 7.5	300	160	1.7 ± 0.2	69.2 ± 13.7	24.3 ± 4.4

Average height for Harkidoon trek was 9241.5 feet, Deoriatal-Chandrasheela was 8005.5 feet, Kuari pass was 10093 feet and Kedarkantha was 9049 feet. [Table 5]

Data record of four different Himalayan treks was taken into account. Average height of each trek based on various campsites was calculated. Average height for Harkidoon trek was 9241.5 feet, Deoriatal-Chandrasheela was 8005.5 feet, Kuari pass was 10093 feet and Kedarkantha was 9049 feet. [Table 5]. Of all four physiological variables studied for all trekkers, average values of systolic BP, diastolic BP, SpO_2 and Pulse for each trek were calculated spanning across all campsites. Systolic BP averages ranged from 127± 21.5 mmHg to 135.3 ± 13.7 mmHg. Diastolic BP averages ranged from 88.7± 11.1 mmHg to 91.5 ± 6.7 mmHg. SpO2 averages ranged from 91.8± 3.8 to 94.7 ± 1.4. Pulse averages ranged from 94.6±9.3 to 106.7±20.1. [Table 5]

Difference between these physiological variables amongst all trekkers was also calculated. Difference was statistically highly significant for variation in systolic BP, SpO_2 and Pulse while it was not significant for diastolic BP. [Table 6]

Each trek was compared with another trek. Difference in the physiological variables was calculated with regard to difference of average heights of these treks. Difference remained statistically highly significant for the same variables i.e. systolic BP, SpO_2 and Pulse

Table 5 – Changes in BP, SPO_2 and Pulse with each campsite of the trek

Trek name	Campsite #	Altitude (feet)	Systolic BP		Diastolic BP		SPO_2		Pulse	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Har Ki Dun (n=21)	Campsite 1	6397	129.2	10.5	87.0	9.1	96.8	0.4	85.6	9.4
	Campsite 2	8280	128.4	8.5	92.6	6.8	94.7	1.7	104.4	14.5
	Campsite 3	8956	131.6	8.2	93.1	6.2	92.8	0.6	107.6	2.4
	Campsite 4	11768	133.8	7.4	93.5	5.4	90.1	1.2	103.2	5.1
	Campsite 5	11768	127.6	7.4	91.8	5.4	94.0	0.7	101.6	1.8
	Campsite 6	8280	126.2	7.4	91.0	5.2	96.5	0.6	99.9	5.0
	Average	9241.5	129.4	8.5	91.5	6.7	94.1	2.4	100.4	10.3
Deoriatal-Chandrashee la (n=373)	Campsite 1	6601	131.3	12.2	86.8	7.8	96.6	0.2	87.2	2.7
	Campsite 2	7841	134.3	13.9	91.8	9.4	94.9	0.8	103.4	6.0
	Campsite 3	8891	134.2	13.7	91.5	8.4	94.3	1.1	103.6	4.8
	Campsite 4	8790	133.1	12.1	91.3	8.7	93.8	0.7	102.2	4.4
	Campsite 5	8790	143.5	13.2	94.9	5.9	93.8	1.4	97.7	6.4
	Average	8005.5	135.3	13.7	91.3	8.5	94.7	1.4	98.8	8.0
Kuari Pass (n=25)	Campsite 1	7601	120.2	12.5	83.0	10.5	92.0	5.7	107.1	11.5
	Campsite 2	10640	129.8	17.7	88.0	10.6	91.2	2.1	94.5	4.4
	Campsite 3	11031	123.6	29.3	96.0	8.1	90.4	2.8	103.3	2.3
	Campsite 4	11100	134.3	21.5	88.1	11.6	93.5	3.1	121.9	33.5
	Average	10093	127.0	21.5	88.7	11.1	91.8	3.8	106.7	20.1
Kedarkantha (n=41)	Campsite 1	6750	128.3	11.0	89.8	8.4	95.8	0.0	80.9	0.0
	Campsite 2	9230	131.4	13.1	90.9	9.7	92.3	1.8	99.3	1.6
	Campsite 3	11256	128.3	10.1	91.5	10.4	90.9	2.1	103.0	8.3
	Campsite 4	8960	129.1	10.8	87.9	5.7	92.5	2.7	95.2	1.6
	Average	9049	129.3	11.3	90.0	8.8	92.9	2.6	94.6	9.3

Table 6 – Difference between physiological variables in all four treks

Difference in Systolic BP	Highly significant (F=5.6, p<0.001)
Difference in Diastolic BP	Not significant
Difference in SPO2	Highly significant (F=30.8, p<0.001)
Difference in Pulse	Highly significant (F=9.1, p<0.001)

**based on one way-ANOVA*

especially when the height difference between treks was more than 1000 feet (p<0.01). In a couple of comparisons where the average height difference was less than 1000 feet, the difference between variables was still significant ($p \leq 0.05$). Inter-trek comparison of diastolic BP was not statistically significant despite of height difference [Table 7].

Discussion: With the recently increased popularity of high-altitude treks, numerous agencies have come up but least regard is paid to safety and medical conditions of trekkers. Though globally there have been extensive research on topics of high-altitude and related medical conditions, in India, there's still severe dearth of such research. Theories of physiology are available in books but on-field corroboration with findings is necessary and it can open a whole new area of medical research on high-altitudes.

Four different treks with different altitudes were studied in present study. In some treks, data of few batches were available while in some, data of single batch were available. However, cumulative sample size was more than 450 and results found were also interesting.

Table 7 – Statistically significant difference between variables amidst treks

Statistically significant difference between variables amidst treks				Average height difference of trek (in feet)
Systolic BP	Har Ki Dun &Deoriatal-Chandrasheela	Significant	t=2 at 95% CI, p=0.05, df=392	1236
	Deoriatal-Chandrasheela&Kuari Pass	Highly significant	t=-2.8 at 95% CI, p<0.01, df=396	2087.5
	Deoriatal-Chandrasheela&Kedarkantha	Highly significant	t=-2.7 at 95% CI, p<0.01, df=412	1043.5
Diastolic BP	-	No statistically significant difference in between treks	-	-
SPO_2	Har Ki Dun &Kuari Pass	Significant	t=-2.4 at 95% CI, p<0.05, df=44	851.5
	Deoriatal-Chandrasheela&Kuari Pass	Highly significant	t=-8.5 at 95% CI, p<0.01, df=396	2087.5
	Deoriatal-Chandrasheela&Kedarkantha	Highly significant	t=-7 at 95% CI, p<0.01, df=412	1043.5
Pulse	Harki Dun &Kedarkantha	Significant	t=-2.2 at 95% CI, p<0.05, df=60	192.5
	Deoriatal-Chandrasheela&Kuari Pass	Highly significant	t=4.2 at 95% CI, p<0.01, df=396	2087.5
	Deoriatal-Chandrasheela&Kedarkantha	Highly significant	t=-3.1 at 95% CI, p<0.01, df=412	1043.5
	Kuari Pass and Kedarkantha	Highly significant	t=-3.3 at 95% CI, p<0.01, df=64	1044

**based on one way-ANOVA*

High-altitude Himalayan treks are a great way to unwind self, manage stress, explore nature and improve upon spiritual health. While these high-altitude treks are popular amongst youngsters and students, people in their 40s are also not lagging behind in India. Campsite stays are little difficult on body. Along with menstrual challenges and other feminine issues, it might be little more difficult for females but it's heartening to see female proportion of trekkers to be as much as 35% amongst all study Participants. Numbers can only go up from here.

Without awareness, many people straightaway jump into doing high-altitude treks without any preparation, training or physical fitness. While pre-trek fitness certification is mandatory with some agencies, it's a neglected area with many other agencies. In current study, average BMI was almost 25 which is borderline overweight. As many as 38% of study Participants were either obese or overweight. Excessive weight can have lot of untoward effect on the body at high altitudes in both ascent and decent and it can prove detrimental as well. Awareness regarding fitness and pre-trek check-up is imperative. A high-altitude trek is classed as above 2,500m or 8202 feet. Thus, three out of four treks studied were high-altitude treks while the fourth one was almost a high-altitude trek.

It is observed that average systolic blood pressure of a higher altitude trek (Harki dun, Kauri pass and Kedarkantha) is significantly lower when compared individually with a lower altitude trek (Deoriatal Chandrasheela) as seen in Table 7. This is because we have compared an average of a whole trek. If you observe within each trek, average systolic blood pressure initially increases as height of the trek increases from one campsite to the subsequent higher campsite [Table 5]. It is not uncommon for lowland visitors to experience temporary high blood pressure at high altitude. This may be due to higher levels of adrenaline or stress hormones in the body because of lower oxygen levels. It usually returns to individual's baseline blood pressure after few days to one week's duration.[2] Therefore, in most of the treks with a few exceptions, we again observe lower average systolic blood pressure even if the

altitude of that subsequent campsite is higher [Table 5].

Differences observed in average SpO_2 and Pulse rate between lower and higher altitude treks coincide with some research studies[3, 4]. A series of physiological responses help to maintain adequate tissue O_2 delivery and supply at high altitude, through a process called 'acclimatization'. Its efficacy depends on the duration of individual's exposure to altitude, age, sea level partial pressure of oxygen in arterial blood (PaO_2) and minute ventilation.[5] The increase in heart rate is related to increased sympathetic activity and vagal withdrawal. Acclimatization mechanisms impose an increased workload on the cardiovascular system, but there is meagre data to establish actual risk of adverse cardiovascular and other life-threatening events due to such physiological phenomena. We strongly advocate more robust biomedical research in this regard, particularly since ever increasing large number of individuals explore high altitude locations, which include overweight people, people with sedentary life style, elderly and even people with diseases.

Studies are conducted in highlanders like *Sherpas* on how their pulmonary capacities evolve since birth to cope up with tough demands of high altitudes. Treks at high altitudes especially in Himalayas are now a thriving industry. Majority of the trekkers are lowlanders from various parts of the country whose bodies function differently than the highlanders. Every year, these treks are frequented by lowlanders from various parts of India and even from abroad in high numbers. Careful recording of physiological variables, meticulous data keeping and subsequent analysis can go a long way in unraveling few more facts and can help us understand and prepare better for this thriving industry of new tourism. Current study is based on all secondary data. Even though one can find inadequacies in the information generated in the present study, it is an humble attempt to try and generate some meaningful information, that can create a much-required base to scale up medical research in high altitude.

Conclusion: Almost 40% study subjects did not have favourable BMI. Physiological variables show significant changes at high altitudes, especially systolic BP, SPO2 and Pulse. Diastolic BP change with height but difference is not significant. In recent years, interest in adventure sports and excursions has risen. There is a rising trend amongst youth for high-altitude Himalayan trek. Fitness and trek preparedness are often neglected before such treks which can eventually hamper the the whole experience and can even cause consequences at such heights.

Acknowledgment: We are thankful to Indiahikes (www.indiahikes.com) for providing all the data of these treks. We also extend our gratitude to those anonymous trekkers without whom this research would not have been possible.

References:

1. Medical Research At High Altitude; Rao Ks, Apte Cv; Med J Armed Forces India. 1995;51(2):81–82. Doi:10.1016/S0377-1237(17)30933-4
2. Pre-Existing Medical Conditions At Altitude; Institute For Altitude Medicine At Telluride; (Http://Www.Altitudemedicine.Org/Altitude-And-Pre-Existing-Conditions).
3. Heart Rate Variability Changes At 2400 M Altitude Predicts Acute Mountain Sickness On Further Ascent At 3000–4300 M Altitudes;Karinen HM, Uusitalo A, Vähä-Ypyä H, Kähönen M, Peltonen JE, Stein PK, Viik J and Tikkanen HO; 2012; Frontiers in Physiology; 3:336. doi: 10.3389/fphys.2012.00336
4. Effect Of Altitude On The Heart And The Lungs; Peter BäRTSCH J. Simon R. Gibbs; Circulation VOL. 116 ISSUE 19 (2007) PP: 2191-2202 Published BY Lippincott Williams & Wilkins
5. Clinical recommendations for high altitude exposure of individuals with pre-existing cardiovascular conditions: A joint statement by the European society of cardiology, the council on hypertension of the European society of cardiology, the European society of hypertension, the International Society of Mountain Medicine,.
6. Basnyat, *et al*; European Heart Journal, Volume 39, Issue 17, 01 May 2018, Pages 1546–1554,https://

Conflict of interest: None

Funding: None

Cite this Article as: Joshi U, Shukla A, Kariya V. Changes In Vital Signs Of Lowlanders -A Study Of Four High-Altitude Himalayan Treks. Natl J Integr Res Med 2019; Vol.10(4): 73-77