

## Association Of Body Mass Index and Haemodynamic Parameters With Change In Altitude In Healthy Young Adults

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### KEYWORDS

### ABSTRACT

**BACKGROUND:** Environmental conditions play a significant role in an individual's health. It has been suggested that change in environmental conditions and altitude greatly affect human health. Change in environmental factors and unhealthy life style can affect cardiovascular, respiratory and cognitive functions and can lead to various health related problems. There is also an association of change in BMI with altitude. So, the present study was planned to find the association of body mass index and haemodynamic parameters with altitude in healthy young adults.

**AIMS AND OBJECTIVES:** To find out association between Body mass index and haemodynamic parameters (blood pressure and pulse rate) with change in altitude in two groups.

**MATERIAL AND METHODS:** The present study was conducted in the department of Physiology, MMMC&H Kumarhatti, Solan. Our study included 150 subjects and they were divided into 2 groups. Group A comprised of 75 subjects residing permanently at high altitude and Group B, who has been residing in low altitude areas. After informed consent as per the inclusion and exclusion criteria, Haemodynamic parameters were assessed by measuring Blood Pressure (BP) and Pulse rate (PR) and the body mass index (BMI) was calculated for assessment of anthropometric parameters. Collected data was statistically analysed using SPSS computer program for window version 21.0.

**RESULTS:** This study revealed that BMI of the subjects residing in low altitude areas was higher as compared to the subjects residing permanently at higher altitude and it was statistically significant ( $P < 0.01$ ). Systolic BP, diastolic BP and pulse rate was slightly increased in the subjects from low altitude areas, but was statistically non-significant.

**CONCLUSION:** In our study, BMI of the subjects who have been permanently living at low altitude was significantly higher as compared to the subjects who have been permanently residing at high altitude in Himachal Pradesh. Increased BMI is known to result in various health diseases and complications. Findings of our study reinforce the need to adopt healthy life style practices.

### INTRODUCTION

Environmental factors play a significant role in an individual's health. Changes in lifestyles like physical inactivity can lead to various health-related problems. Change in environment conditions acts as a challenge and can affect human health [1]. There is also a link between altitude and changes in BMI. Body mass index (BMI) is a measure to assess obesity [2] Obesity is an important public health concern throughout the world. It has been reported that there occurs significant increase in obesity and central obesity with decrease in altitude. [3]. According to a study it is suggested that the cause of low BMI at high altitude is due to significant decrease in body fat level due to fat catabolism. Results of a study concluded that lower level of Body mass index in the subjects residing at high altitude areas is less which could be due to environmental conditions like low temperature and low oxygen levels which have a direct catabolic effect on BMI.

According to a report by the World Health Organization it has been observed. Obesity is an independent risk factor for many non-communicable diseases (NCD), responsible for 38 million (68%) of the world's 56 million deaths [4]. The body mass index (BMI) is a measure for the estimation of body fat, the higher level of BMI lead to greater risk of developing obesity related health problems. Obesity is crucial factor for the development of hypertension, Type 2 diabetes mellitus and cardiovascular disease. The relationship among cardiovascular disease (CVD), obesity and diabetes tend to develop at a relatively young age [5] [6]. It has been suggested that changes in environmental conditions greatly affect human health. People residing at high altitude areas

tend to have lower body mass index (BMI) as compared to people in low-altitude areas. However, it has been observed that an increase in altitude is associated with an increase in Basal metabolic rate (BMR) and an increase in the leptin levels in the body which leads to less energy intake due to lack of appetite. [7] It has been reported that the mortality rate due to cardiovascular disease, cancer, Alzheimer's disease, and stroke is lower in people permanently residing in high-altitude areas[8].

Changes in environmental conditions have also been seen to alter haemodynamic parameters [9] Short-term and long-term exposure to altitude results in changes of cardiovascular function. Literature has shown that people living at a moderate altitude from a long period of time have lower risk for cardiovascular and respiratory diseases [10] There is evidence that suggests that inhabitants of high altitude have cardiovascular and respiratory adaptations which are advantageous for high altitude living. It has also been observed that acute exposure to altitude causes an increase in cardiac output with tachycardia, but cardiac output returns to normal after a few days of acclimatization[11] Another study showed that long term living in dry and hot climates seem to have little impact on haemodynamic parameters [12] Studies have reported that obesity and overweight are quite prevalent in students [13] Poor lifestyle factors are thought to account for an increase in body mass index in students. Changes in altitude may also influence BMI. It has been seen that people living in higher altitude had a lower risk of developing obesity [14].

The interaction between human health and the environment have been proven to significantly impact human health [15] Various health diseases are seen in adults due to unhealthy life style practices. There is a common occurrence of various non communicable diseases like obesity, hypertension, dyslipidaemia also in adults due to their life style behaviour[16] A study on medical students have shown prevalence of pre-hypertension , hypertension and other cardiovascular diseases at an early age [17] Various factors like climate change, poor air quality, temperature related illness, disastrous weather events contributing to infection and overall destabilization of the global ecosystem is the greatest health threat to the human population [18][19].

There is incongruity about the fact that whether hypoxia prompts weight reduction or not. Studies have been conducted at a variety of altitude ranges: moderate, high, and extreme altitudes but there is a dearth of literature that can verify the association between different ranges of altitude and the prevalence of obesity and its association with hemodynamic parameters. In this context, how the environmental factors and altitude affect weight gain. So, the present study was planned to find out the effect of moderate altitude on body mass index and haemodynamic parameters in young adults.

## **MATERIAL AND METHODS**

The present study was conducted in the Department of Physiology, Maharishi Markandeshwar Medical College and Hospital Kumarhatti, Solan. Ethical approval was obtained from Institutional Ethical Committee (IEC). After explaining the purpose and methodology of the study, all eligible subjects were requested to participate in the study and a written informed consent was taken. In this study, a sample size of 150 subjects was enrolled in the study and they were divided into two groups Group I and Group II based on inclusion and exclusion criteria. The subjects excluded from the study were those:

- Suffering from any neurological or psychiatric disorder or sleep disorder.
- Any endocrinological disorders.
- Any visual or auditory disorder
- Any major illness viz. hypertension, diabetes mellitus, heart diseases etc.
- Any haematological diseases.
- Any chronic medical problem.
- Any sedative medicine intake.
- Any history of chronic smoking or alcohol addiction.

In the present study assessment of Body mass index (BMI) and hemodynamic parameters (Pulse & blood pressure) were measured.

### **Body Mass Index**

BMI is an important factor for the assessment of body fat to an individual's height and weight. BMI was calculated using anthropometric parameters (height and weight). Height and weight measurements of the subjects were used to calculate BMI. Body mass index was calculated by using the formula, body weight in kilograms divided by the square of height in meters. Weight assessment was done by using a standardized Analogue weighing machine. It was ensured that the weighing equipment recorded zero before the person was positioned on it. The weight was recorded in kilograms. Measurement was done using a standardized stadiometer. The height of the subject was noted in centimetres[20].

### Hemodynamic parameters

Hemodynamic parameters include assessment of pulse rate and blood pressure. Pulse rate was recorded in resting position by examining radial pulse. The pulse rate was counted for one minute using a watch. Three readings were taken and the average of three readings was taken as the resting pulse rate.

Blood pressure was measured using a standardized stethoscope and sphygmomanometer. Before starting the procedure, the subjects were made to sit comfortably on the examination couch for at least five minutes. Necessary precautions were taken as per standard recommendations. BP recording was done using the palpatory method followed by the auscultatory method. Three readings were taken for both Systolic blood pressure (SBP) and Diastolic blood pressure (DBP) at an interval of 5 minutes and average of three readings was taken as final reading[21].

### RESULTS:

In the present study 150 healthy subjects were recruited in the study and they were divided into two groups Group I (subjects residing at high altitude) and Group II (subjects residing at low altitude). Each group consists of 75 study subjects.

#### A. DEMOGRAPHIC PROFILE

##### Age

**Table 1: Comparison of age between Group I and Group II subjects**

Study group (N=75)	Mean age	P -value
Group I	20.57±1.24	0.080
Group II	20.21±1.21	

Table 1 shows the overall mean and standard deviation of age. In our study, mean age of Group I was 20.57±1.24 and Group II was 20.21±1.21; (P=0.080). On comparing, it has been observed that there was no age based difference between the two groups.

##### 2. Gender

**Table 2: Gender based distribution of Group I and Group II subjects**

Gender	Group I (N=75)	Percentage	Group II (N=75)	Percentage	P value
Male	33	44 %	24	32%	0.157
Female	42	56 %	51	68%	

Table 2 shows the distribution of study subjects according to their gender. In our study, 42 students (56%) were females and 33 students (44%) were males in group I. In group II 51 students (68%) were females and 24 (32%) students were males. On comparison there was no gender-based difference between the two groups (P=0.157).

**Table 3 shows Comparison of BMI in Group I and Group II subjects**

Study group	Number (n)	Mean BMI (Kg/m <sup>2</sup> )	P value
Group I	75	22.50±3.80	<b>0.010*</b>
Group II	75	25.45±2.73	

In our study BMI of adults living at high altitude areas (Group I) was 22.50±3.80 kg/m<sup>2</sup> and BMI of adults residing at low altitude areas (Group II) was (25.45±2.73 kg/m<sup>2</sup>). Body mass index (25.45±2.73) of young adults living at low altitude areas was significantly higher as compared to adults permanently residing at high altitude areas (22.50±3.80) i.e (P <0.01).

**Table 4: Comparison of Pulse rate between Group I and Group II subjects:**

Parameter	Study Group	Number	Mean	P- Value
Pulse (beats/min)	Group I	75	72.43±6.24	0.790
	Group II	75	72.21±3.38	

Table 4 shows the comparison of pulse rate between Group I and Group II subjects. In our study, we observed that mean pulse rate of Group I subjects was 72.43±6.24 and of Group II subjects, it was 72.21±3.38. On

comparison it was seen that mean pulse rate difference of Group I & Group II subjects was not statistically significant (P=0.790).

**Table 5: Comparison of Blood pressure between Group I subjects and Group II**

BLOOD PRESSURE	GROUP	NUMBER	MEAN	P-VALUE
SBP (mmHg)	SBP (Group I)	75	117.36±4.80	0.651
	SBP (Group II)	75	120.92±6.95	
DBP (mmHg)	DBP of (Group I)	75	76.54±5.56	0.399
	DBP of (Group II)	75	77.16±3.02	

Table 5 shows comparison of blood pressure in Group I and Group II subjects. In our study, we observed that in the subjects from high altitude areas (Group I) Systolic BP was 117.36±4.80 and Diastolic BP was 76.54±5.56. In the subjects from low altitude areas (Group II), Systolic BP was 120.92±6.95 and Diastolic BP was 77.16±3.02. On comparing SBP between Group I and Group II subjects, SBP of Group I subjects was slightly less than the subjects from Group II subjects, but statistically it was not significant (P=0.651). Similarly, on comparing DBP of Group I and Group II subjects, DBP of Group I subjects was slightly less than Group II subjects. On observation, it has been seen that the values DBP were not statistically significant (P=0.399).

### Discussion

The results of the present study concluded that the subjects who have been residing permanently at high altitude have significantly lower BMI than subjects, residing at low altitude environments (P<0.01). It was also seen that both systolic and diastolic blood pressure in the subjects living at high altitude was less when compared to the subjects living at low altitude but it was not significant. BMI is an important factor for the assessment of body fat in relation to an individual's height and weight. Increased BMI was observed in adults living at low altitudes which could be due to the reason that people living in low-altitude areas have unhealthy lifestyles, increased intake of unhealthy food and sedentary lifestyles which increases the risk of obesity. This could be attributed to the fact that changes in body composition and weight loss frequently occur when humans are exposed to hypoxic environments. The mechanisms thought to be responsible for these changes are increased energy expenditure resulting from increased basal metabolic rate high levels of physical activity and inadequate energy intake.[22] The severity of hypoxia, the duration of exposure as well and the level of physical activity also play crucial roles. It has been seen that populations living at higher altitudes have increased resting metabolic rate, negative energy balance in hypoxia and reduction in energy intake from a lack of appetite. Eating less leads to body size reduction and subsequently to being able to survive with smaller oxygen consumption and also having lower BMI. [23] In the present study it was observed that BMI of young adults living at high altitude permanently was less as compared to the adults from low altitude areas. Reason for lower BMI in people who live in hilly areas could be due to the fact that they often travel on-feet, prefer to choose healthy diet at least during earlier life. It has been suggested that high altitude hypoxia inducible factors cause increase in energy expenditure which result in increased BMI is known to result in various health diseases and complications[24].

A study suggested that high altitude hypoxia inducible factors cause increase in energy expenditure which result in weight loss. This could be due to upregulation of leptin level and enhance leptin sensitivity. Enhanced leptin sensitivity at high altitude suppresses appetite and results in weight loss due to enhanced energy expenditure[25]. On prolonged exposure to high altitude it causes increase in the concentration of plasma non-epinephrine which suppresses the blood flow in the intestine and thus restricts appetite[26]. In our study increased BMI was observed in students living at low altitude which could be due to the reason that students living at low altitude areas have unhealthy life style, increase intake of unhealthy food and sedentary life styles which increases the risk of obesity. Literature has reported that the prevalence of obesity is less in inhabitants of higher altitudes[27]. A study reported that excess of BMI is associated with an increased risk of cardiovascular complications[28].

In our study haemodynamic parameters i.e pulse rate & blood pressure of Group I and Group II subjects was assessed. On comparison it was seen that mean pulse rate of adults residing at high altitude was not statistically significant as compared to adults residing at low altitude (P=0.790). It was also found that SBP of the subjects living at high altitude areas was slightly less than the subjects living at low altitude areas, but statistically it

was not significant ( $P=0.651$ ). On comparing DBP of both the study groups, the Diastolic blood pressure of the subjects living at high altitude areas was slightly less than the subjects residing at low altitude areas and it was observed that the values DBP were not statistically significant ( $P=0.399$ ). Results are consistent with previous study which observed that after years of stay at high altitude there was no significant effect in Systolic blood pressure. [29] A study reported that excess of BMI is associated with an increased risk of cardiovascular complications. [30] Another study has reported that Systolic blood pressure of individuals living at high altitude is less as compared to residents living at lower altitude. It has been documented that after exposure to moderate altitude of about 2950 m, there was no significant difference found in cardiovascular parameters[31]. In a study it is reported that after few years of residing at high altitude, blood pressure of an individual will be lower at high altitude than the people living at sea level and their blood pressure remains lower in population living at higher altitude than the low altitude populations[32]. Contradictory results have been observed by a study, in which there was increase in Systolic and Diastolic blood pressure when humans were exposed to high altitude environment. This could be due to reduced hypobaric pressure which leads to decreased amount of oxygen which causes an increase in blood pressure[33]. The mechanisms involved in BP control in response to hypoxic changes are complex. Travelling from lower to higher altitudes, body of an individual initially develops various responses to help a person to adapt to the hypoxic environment. There occurs increase in breathing and heart rate. Pulse rate and BP go up rapidly as heart pumps faster to provide more oxygen to the cells. Later as a defensive response acclimatization takes place. Extra red blood cells are produced to transport more oxygen. The lungs expand to facilitate the osmosis of oxygen and carbon dioxide. There is also an increase in the vascular network which increases the transfer of gases[34].

It has been reported that with increase in altitude there is initial hypertension followed by gradual decrease in blood pressure towards normal with acclimatization. [35] In our study, no significant change was seen in blood pressure after several years of living at high altitude in the subjects residing at high altitude areas as compared to the subjects residing at low altitude areas but it is on lower side. This could be attributed to the mechanism of acclimatization. Acclimatization causes various physiological adaptations in people living in higher altitudes as they have a distinct suite of physiological traits which make them proficient to tolerate environment hypoxia. [36] Acclimatization mechanism involve relaxation of vascular smooth muscles, increase in collateral circulation, high red blood cells and increased haemoglobin level [37]. Another reason for preservation of normal BP in adults living at higher altitudes can be explained by the normalization of total peripheral resistance by enhanced neovascularisation.[38] Previous literature has shown that inhabitants living at higher or moderate altitude have evolutionary genetic adaptations to altitude, because these inhabitants maintain higher arterial oxygen saturation by birth even at rest. They also show less loss of aerobic performance with increasing altitude. [39]

According to a study it is estimated that increased body mass index in young adults is associated with increased risk of having cardiovascular diseases. Life style is considered as an important factor of health in recent times.[40] It has been seen that people residing at low altitude areas follow unhealthy lifestyle practices and hence they are more prone to encounter illness and various health related problems. Unhealthy life style and increased BMI play an important role in causing various health related issues such as cardiovascular diseases, metabolic diseases, hypertension, over weight and so on even at younger age [41]. Change in environmental conditions like climate, air quality, vegetation and life style effect human health. Findings of our study emphasize the need to adopt healthy lifestyle, healthy eating habits and physical activity on daily basis. Moreover, the healthier the younger populations, the more productive they are for their developing societies.

## **CONCLUSION**

The results of our study concluded that there is increased BMI in healthy young adults living at low altitude environments. Increased BMI play an important role in causing various health related issues such as obesity and cardiovascular complications even at younger age. Awareness should be provided to the younger population about the adverse effects of increased body mass index on health since change in environment conditions like climate, air quality, vegetation and life style affect human health. They should be encouraged to adopt healthy life style, healthy food habits and regular physical activity. Findings of our study emphasize the need to adopt healthy lifestyle, healthy eating habits and physical activity on daily basis. Moreover, the healthier the younger populations, the higher the educational environment and the more productive they are for their developing societies.

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