IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 4 Ser. 2 (April. 2019), PP 79-83
www.iosrjournals.org

A Study of the Effect of the Seasonal Variation on Blood Pressure among Healthy Individuals

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Abstract
Introduction
The changes in BP with changes in weather occur through different mechanisms, in the form of increased BP during winters and decreased BP during summer. This study is planned with the objectives of assessing the seasonal variation in blood pressure and its association with nutritional status (BMI) in healthy population.
Materials & Methods
The study was conducted in Department of Medicine, People's College of Medical Science & Research Center, Bhopal from December 2016 to June 2018. Normotensive individuals aged 18-80 years and giving consent were included in the study.
All participants were enrolled after taking written informed consent. BP of the participants was recorded once during the predefined summer (15April-15June) and once during the winter (15December-15February) periods. BP measurement was done by Digital BP instrument (Omron) in sitting position after resting for 5 minutes. The data was compiled using Ms Excel and analysed using Epi Info 7.2 software.
Observations & Results-
Statistically significant difference in mean systolic and diastolic BP during winter and summer was found (p=0.0001).
Statistically insignificant association was found between BMI and SBP of winter and summer with normal (p=0.0001) and overweight (p=0.001) BMI category. Also statistically significant association was found between DBP of winter and summer with normal (p=0.067) and overweight (p=0.002) BMI category.
Conclusion *In hypertensive participants, significant association was found between BMI and seasonal variation in SBP and DBP in normal and overweight but no statistical association was found between BMI and SBP / DBP in underweight and obese participants.*

Date of Submission: 20-03-2019 Date of acceptance: 06-04-2019

I. Introduction

Hypertension is one of the most common non-communicable disease with rising incidence in both the developing and the developed world.[1] Hypertension exerts a substantial public health burden on cardiovascular health status and healthcare systems in India. It is directly responsible for 57% of all stroke deaths and 24% of all coronary heart disease (CHD) deaths in India.[2] A large proportion of these cases remain either undiagnosed or untreated and present directly as one of the complications.[3]

Such incidences are more common in winter than in summer. The changes in BP with changes in weather occur through different mechanisms, in the form of increased BP during winters and decreased BP during summer.[4] Winters have been known to have a higher incidence of intracranial hemorrhage (ICH) and myocardial infarction (MI).This observation is attributed to multiple physiological changes that occur during winter, such as increased sympathetic activity alteration in the endothelial dysfunction, and increased blood pressure (BP).[5]

There is growing evidence that environmental temperature is a major determinant of the observed seasonal fluctuations in blood pressure with increase and decrease BP in winters and summers respectively.[6] Thermoregulatory vasoconstriction, which increases arterial BP significantly, is an adaptive response to provide enhanced circulatory function due to the protective mechanisms that are activated to maintain temperature in cold weather (non-shivering thermogenesis and increased metabolic rate). Elevation of BP induced by a longer period of cold exposure is not reversible after return to a thermo-neutral temperature in animal studies and may result in cold induced hypertension.[7] The diameter of blood vessels constricts in cold temperatures, causing the heart to work harder to push blood through the arteries and veins, leading to an increase in both systolic and diastolic readings.[8]

Most of the studies are done in western countries with extreme cold temperatures on hypertensive patients. Very few studies have been done in Indian population and none done with focus on decrease in BP in summer. Therefore, this study is planned with the objectives of assessing the seasonal variation in blood pressure and its association with nutritional status (BMI) in healthy population.

Objectives:

1. To compare the variation in systolic and diastolic BP between summer and winter in study group
2. To determine association between seasonal change in BP and BMI

Materials & Methods

The present study was conducted in Department of Medicine, People's College of Medical Science & Research Center and associated People's Hospital, Bhopal for the period of 18 months from December 2016 to June 2018. The city was hottest in May and June (mean maximum and minimum temperature: 40.6°C and 26.3 °C). The coolest months were December and January (mean maximum and minimum temperature: 25.1°C and 11.2°C). This information was obtained from the meteorological department, Government of India.

Normotensive individuals aged 18-80 years and giving consent were included in the study. The study group comprised of healthy population who were not on any type of medication whose BP was within normal range during the first examination for recruitment and who never had previous record of high BP or history of taking any anti-hypertensive medication.

Sample size and follow up: As there was no study available on seasonal deviation in central India, prevalence of Hypertension was taken to calculate sample size. For a mean systolic B.P. difference of 4.5 mm of Hg and S.D of 5.1 between summer and winter, (based on study of Kristal- Boneh et al. with permissible error of 1% and power 95%, minimum sample size worked out to be 46. Considering the risk of loss on follow-up, upto 20-30%, minimum sample size was calculated to be 61. Hence a total of 75 participants were recruited in the study. All participants were enrolled after taking written informed consent. BP of the participants was recorded once during the predefined summer (15April-15June) and once during the winter (15December-15February) periods. BP measurement was done by Digital BP instrument (Omron) in sitting position over right brachial artery with arm at the level of heart after resting for 5 minutes. Two readings were recorded at an interval of 1 minute, and the mean of the readings was used to represent the BP.

All the participants were requested to remove the clothing to expose the arm site of cuff placement, comfortably seated, with legs uncrossed, and the back and arm supported, such that the center of the cuff applied on the upper arm was at the level of the heart. During the study days the subjects were asked not to change their regular way of life. Care was taken that the person had not smoked or taken tea or done vigorous exercise in previous ½ hour. Height (in cm) and weight (in kg) of all participants were measured at the first contact and BMI was calculated using the formula -BMI = weight (kg)/ height (m) ^{2}. The data was compiled using Ms Excel and analysed using Epi Info 7.2 software.

Observations & Results-

A total of 75 participants were registered in the study and followed up in the study. Participants who lost to follow up were excluded from the study

Table 1- Distribution of study participants according to Sociodemographic variables

Sociodemographic variables		Frequency	(%)
Age group (years)	<30	26	34.7
	30-39	24	32
	40-49	13	17.3
	50-59	9	12
	≥60	3	4
Gender	Male	59	78.7
	Female	16	21.3
BMI	Underweight (<18.5)	2	2.7
	Normal	29	38.7

	(18.5-24.9)		
	Overweight (25-29.9)	34	45.3
	Obese (≥30)	10	13.3

Mean age of participants was 36.3±11.5 years. Majority of the participants (34.7%) belonged to <30 years followed by 32% participants in age range of 30- 39 years.
In present study, 78.7% were male and 21.3% were female. Mean BMI of participants was 25.5±3.8 kg/m^2 and 45.3% participants respectively were overweight.

Table 2-Seasonal Variation in Mean BP

Mean of BP (mm Hg)	Winter (n=75)	Summer (n=75)	p value
Mean SBP	120.55±9.11	116.77±9.57	0.0001
Mean DBP	75.52±6.55	72.79±7.19	0.0001

The mean systolic BP during winter was 120.55±9.11 mmHg and that during summer was 116.77±9.57mmHg. Similarly mean diastolic BP during winter and summer was 75.52±6.55mmHg and 72.79±7.19mmHg respectively. Seasonal variation in mean SBP was 3.78 mmHg and 2.73 mmHg in DBP. Test of significance showed statistically significant difference in mean systolic and diastolic BP during winter and summer in normotensive group (p=0.0001).

Table 3-Seasonal variation of BP as per JNC VII criteria

BP		**Winter (n=75)**		**Summer (n=75)**		**p value**
		Frequency	%	Frequency	%	
Systolic	Pre-hypertension (BP= 120-139 mm Hg)	42	56	35	46.7	0.25
	Normal range (<120 mm Hg)	33	44	40	53.3	
Diastolic	Pre-hypertension (BP = 80-89 mm Hg)	28	37.3	18	24	0.07
	Normal range (<80 mm Hg)	47	62.7	57	76	

Out of 75 participants, 56% participants had SBP in the range of 120-139 mmHg (pre-hypertensive) during winters which was decreased to 46.7% during summers. There was relative decrease in frequency of prehypertensive category for SBP in summer as compared to winter, however this was not statistically significant. DBP was in the range of 80-89 mmHg (pre-hypertension) in 37.3% participants during winter which was decreased to 24% during summer. There was relative decrease in frequency of prehypertensive category for DBP in summer as compared to winter, however this was not statistically significant.

Table 4-Seasonal Variation in SBP according to BMI

	Winter (mm Hg)	Summer (mm Hg)	p value
Underweight (n=2)	126.50±3.54	109.0±19.8	NA
Normal (n=29)	119.76±10.41	116.0±10.84	0.0001
Overweight (n=34)	121.29±7.84	117.97±7.15	0.001
Obese (n=10)	119.10±10.07	116.50±11.65	0.414

Seasonal variation in mean SBP was 17.50 mmHg, 3.76 mmHg, 3.32 mmHg, 2.60 mmHg in underweight, normal, overweight and obese category according to BMI respectively. Test of significance showed statistically significant difference between SBP of winter and summer with normal (p=0.0001) and overweight (p=0.001) BMI category.

Table 5-Seasonal Variation in DBP according to BMI

BMI	Winter (mm Hg)	Summer (mm Hg)	p value
Underweight (n=2)	84.5±0.71	76.0±14.14	NA
Normal (n=29)	75.97±5.21	73.61±6.68	0.067
Overweight (n=34)	74.68±7.24	71.35±7.45	0.002
Obese (n=10)	75.30±7.35	74.60±6.72	0.749

Seasonal variation in mean DBP was 8.50 mmHg, 2.36 mmHg, 3.33 mmHg, 0.70 mmHg in underweight, normal, overweight and obese category according to BMI respectively. Test of significance showed statistically significant difference between DBP of winter and summer with normal (p=0.067) and overweight (p=0.002) BMI category.

II. Discussions

In present study, the mean age of participants was 36.3±11.5 years. Majority of the participants in participants (34.7%) belonged to <30 years followed by 32% participants in age range of 30- 39 years. The mean age of participants in a study by **Iwahori T et al (2018)** in Japan was 54 years[9], similar to present study.

In present study, 78.7% participants were males and only 21.3% were females. **Iwahori T et al (2018) et al[9]**in Japan reported 83% participants were males and rest were females.

The present study found statistically significant association of seasonal variation and systolic and diastolic blood pressure (p=0.00001). This observation may be explained as a phenomenon of thermoregulation during exposure to cold in winter, leading to vasoconstriction of the subcutaneous blood vessels and increasing the peripheral resistance, which, in turn, augments central blood volume leading to rise in BP. On the other hand in summer, exposure to hotter climate leads to vasodilatation in subcutaneous blood vessels to promote heat dissipation from the body, leading to reduced central blood volume and relative fall in BP.

Charach G et al (2004)[4]in Israel found both systolic and diastolic mean blood pressures were higher during winter compared to summer (165 +/- 11.6 and 90 +/- 13.7 and 134 +/- 47.3 and 74 +/- 8.5 mm Hg, respectively; $p < 0.001$). They found no significant seasonal differences between spring and autumn. They concluded patients aged 65-75 years were unexpectedly more sensitive to winter-summer changes than older patients.**Goyal A et al (2017)[5]**in their study in North India also found increased prevalence of hypertension (systolic BP/diastolic BP $\geq$ 140/90 mmHg) from 10.12% during summer season to more than doubled (23.72%) during winter season in study population

In present study, significant association was found between BMI and seasonal variation of systolic blood pressure with normal (p=0.0001) and overweight (p=0.001) BMI category. Similarly statistically significant association between BMI and variation in DBP for normal weight (p=0.067) and overweight (p=0.002) was found. **Sinha P et al (2010)** in their study observed greater increase in prevalence of hypertension during winter among older females and underweight as well as in females with normal BMI.[10]

Kristal-Boneh E et al (1996) in their study observed that the change in mean systolic blood pressure from summer to winter was inversely associated with body mass index (P= 0.0149). They found no association between diastolic blood pressure change and body mass index.[11] The percentage seasonal variation was significantly greater in lean people (e.g. BMI<22.5) kg/m^2 than non-lean people in a study by **Lewington S et al** in China **(2012)[12]**. The observed difference between present study and reference study may be explained by small sample size of present study as compared to reference study. Also the present study recorded blood pressure only twice over a period of one year; once during winter and other during summer whereas the reference study recorded blood pressure monthly throughout the study period.

III. Conclusion

Seasonal variation in temperature between winter and summer has significant effect on BP in all participants; as there is statistically significant variation in mean SBP & mean DBP during winter and summer. Significant association was found between BMI and seasonal variation in SBP and DBP in normal and

overweight but no statistical association was found between BMI and SBP / DBP in underweight and obese participants.

Limitations

1) Temperature discrepancy – temperature of the office where BP was taken may vary from that of an individual's residence or work place.
2) The BP of study population was measured only 2 times – once in summer and once in winter. It would have been better to have BP monitoring every 1-2 monthly to see the change in BP pattern more appropriately. This will be done in our next part of study under department of Medicine.

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Dr Gajendra Prasad Gupta" A Study of the Effect of the Seasonal Variation on Blood Pressure among Healthy Individuals" IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 4, 2019, 79-83.