ORIGINAL RESEARCH PAPER

Medicine

KEY WORDS: Seasonal variation , Blood pressure ,Hypertension prevalence ,Rural urban difference

EFFECT OF THE SEASONAL VARIATION ON BP AMONG HEALTHY INDIVIDUALS AND HYPERTENSIVE INDIVIDUALS

Dr.Gajendra Prasad Gupta Resident Department of Medicine Peoples Medical College and Hospital Bhopal

Dr Sanjay Kumar Dubey* Assistant Professor Department of General Medicine Govt. Medical College ; Ratlam *Corresponding Author

ABSTRACT

Aim: To find out the seasonal variation [between summer and winter] in BP in healthy and hypertensive individuals and to determine whether there is need to change the dose of anti- hypertensive drug/s in patients with change in season .

Methods: A total of 200 participants were registered in the study, 100 in each hypertensive and normotensive group out of which 44 were lost to follow up over a period of eighteen months. So the final analysis of data was done for 156 participants (81 hypertensive and 75 normotensive)

Results: The mean SBP during winter in hypertensive participants was 155.68±16.97 mmHg and that during summer was 135.73±13.46 mmHg. Test of significance showed statistically significant difference in mean BP during winter and summer (p=0.0001).Seasonal variation in mean SBP was 19.95 mmHg and 11.7 mmHg in DBP among 81 HT participants with both SBP and DBP higher in winter as compared to summer.

Conclusion: Higher outdoor temperature during summer is significantly associated with lower mean BP in hypertensive patients across the age groups. The reduction in BP during higher temperature needed reduction in dose of antihypertensive medications in a few patients. 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, and no statistical association was found between BMI and systolic and diastolic difference in normotensive group.

INTRODUCTION

Hypertension is one of the most common non-communicable disease in today's times with rising incidence in both the developing and the developed world. A large proportion of these cases remain either undiagnosed or untreated and present directly as one of the complications. Such incidences are more common in winter than in summer. Hypertension is known to exhibit a winter peak and summer low.

A variety of explanations have been proposed to account for the seasonal variation in risk factors, such as noradrenalin, catecholamines, vasopressin and vitamin D. However a number of studies have also suggested a significant effect of environment temperature on blood pressure. The seasons considerably influence cardiovascular health. 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).Outdoor temperature is the most important determinant of BP fluctuation and is inversely correlated with it. The climatic conditions in tropical areas are considerably different from those in temperate areas, with extremely hot summers and near zero winters resulting in an unusually large seasonal variation in BP.

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. 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.

Although several studies explored the effects of seasonal variations on BP, few studies have looked at longitudinal BP changes in relation to fluctuations in weather patterns. If there is heterogenicity in weather related BP response, it would be important to know whether variations in intra-individual and inter-individual responsiveness to weather changes can predict long-term risk.

Most of the studies are done in western countries with extreme cold temperatures. 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 age and nutritional status (BMI) in healthy and hypertensive population.

METHODOLOGY

Study setting:

The study was done from the month of December 2016 to June 2018 in Department of Medicine, People's College of Medical Science & Research Center and associated People's Hospital, Bhopal and Govt. Medical College , Ratlam. 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 .http://www.imd.gov.in

Study subjects:

Individuals both Normotensive and Hypertensive (by JNC VIII criteria) aged 18-80 years, were qualified to take part in the study. The cases less than 18 years of age were kept out because the study was intended on adult individual for whom JNC VIII criteria for goal for control of HT was applicable.

The normotensive 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. The hypertensive group comprised of population who were already diagnosed as HT / on anti-hypertensive medication / freshly detected HT.

Sample size and follow up:

As there was no study available on seasonal deviation in central India, prevalence of HTN 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 identified to be 61. To be on safer side, we initially planned to recruit 100 cases each in both

groups. The initial study sample comprised of 200 persons meeting eligibility criteria who consented for the study. However, due to loss on follow-up, the final number of participants for analysis in hypertensive group was 81 and 75 in normotensive group.

Exclusion criteria :

1) Those not willing to participate.
2) Those who were taking oral contraceptive pills or steroids.
3) Those with chronic debilitating disease(cancer, chronic renal disease, heart failure, Tuberculosis),
4) Those taking alcohol daily/ regularly,
5) Those who were pregnant on first or follow up visits,
6) Those with serum creatinine >1.5 mg%,
7) Those diagnosed as secondary HT.

(As these factors might influence BP and confound the assessment of the seasonal variation in frequency of HT).Besides, those participants who were lost to follow up were excluded from final analysis.

Data collection:

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. They were asked to relax and avoid talking during the measurement process.

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 ″ hour. For HT patients, anti-hypertensive drugs and dosage were recorded at every visit and compliance of drugs was recorded. 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}

JNC VII DIAGNOSTIC CRITERIA FOR HYPERTENSION.

Category	SBP mmHg		DBP mmHg
Normal	<120	And	<80
Prehypertension	120-139	Or	80-89
Hypertension, stage 1	140-159	Or	90-99
Hypertension, stage2	>160	Or	>100

In winter dose modification was suggested for HT patients if the BP was >160mmHg systolic OR >100mmHg diastolic (Hypertension stage 2), by increasing the current dose /adding new one. In summer if the BP was <120 mmHg systolic AND <80 mmHg diastolic, participants were advised for follow up and monitoring of BP and readjustment of drugs if needed. Target BP for control of HT was 120-139 mmHg SBP for age less than 60 years and 120-149 mmHg SBP for those of 60 years and above AND 80-89 mmHg DBP.

RESULTS AND OBSERVATIONS

The present study titled **"A Study of the effect of the seasonal variation on BP among healthy individuals and hypertensive individuals"** was conducted in Department of Medicine. A total of 200 participants were registered in the study, 100 in each hypertensive and normotensive group out of which 44 were lost to follow up over a period of eighteen months. So the final analysis of data was done for 156 participants (81 hypertensive and 75 normotensive). The findings of the study are presented below.

Table 1- Distribution of study participants according to gender and age

Gender	Age	Hypertensive (n=81)		Normotensive (n=75)		p value
		Frequency	(%)	Frequency	(%)	
Male	<60	28	34.6	56	74.7	0.0004
	≥60	20	24.7	3	4	
Female	<60	25	30.9	16	21.3	0.04
	≥60	8	9.9	0	0	
Total	<60	53	65.4	72	96	0.00001
	≥60	28	34.6	3	4	

Table 2- Distribution of study participants according to Body Mass Index

BMI	Hypertensive (n=81)		Normotensive (n=75)		p value
	Frequency	Percent	Frequency	Percent	
Underweight (<18.5)	1	1.2	2	2.7	0.23
Normal (18.5-24.9)	30	37.1	29	38.7	
Overweight (25-29.9)	39	48.1	34	45.3	
Obese (≥30)	11	13.6	10	13.3	

Table 3 Seasonal Variation in Mean BP amongst Hype rtens I've Participants

Mean of BP (n=81)	Winter (mm Hg)	Summer (mm Hg)	p value
Mean SBP	155.68±16.97	135.73±13.46	0.0001
Mean DBP	94.60±11.64	82.90±8.350	0.0001

Table 4 Seasonal Variation in Mean BP amongst Normo ten sive Participants

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

Table 5- Association of BMI with seasonal variation in systolic BP in winter and summer amongst participants of hypertensive group

BMI	Systolic BP				p value
	Winter (n=81)		Summer (n=81)		
	Controlled	Uncontrolled	Controlled	Uncontrolled	
Underweight (n=1)	0 (0)	1 (1.2)	1 (1.2)	0 (0)	NA
Normal (n=30)	5 (6.2)	25 (30.9)	22 (27.2)	8 (9.9)	0.0003
Overweight (n=39)	6 (7.4)	33 (40.7)	25 (30.9)	14 (18.5)	0.0001
Obese (n=11)	3 (3.7)	8 (9.9)	7 (8.6)	4 (4.9)	0.09

Table 6- Distribution of participants according to systolic BP as per JNC VII classification

Systolic BP (mm Hg)	Hypertensive (n=81)		Normotensive (n=75)	
	Winter	Summer	Winter	Summer
<120	2 (2.5)	5 (6.2)	33 (44)	40 (53.3)
120-139 (Pre-HT)	9 (11.1)	46 (56.7)	42 (56)	35 (46.7)
140-159 (Stage I HT)	36 (44.5)	27 (33.4)	0 (0)	0 (0)
≥160 (Stage II HT)	34 (42)	3 (3.7)	0 (0)	0 (0)
p value	0.0001		0.6	

Table 7 - Hypertensive participants requiring increase in anti-hypertensive dosage/drugs in winter.

BP (mm Hg)	Winter n = 81(%)	Summer n = 81(%)
Systolic ≥160	34 (41.9)	3 (3.7)
Diastolic ≥100	33 (40.7)	3 (3.7)

Table 8- Hypertensive participants requiring decrease in anti-hypertensive dosage/drugs in summer (Systolic < 120 mm Hg & Diastolic < 80 mm Hg)

Age groups (n)	No. of participants
<60 years (53)	2 (3.77 %)
> 60 years (28)	2 (7.14%)
All age groups (81)	(4.9 %)

RESULTS

The mean SBP during winter in hypertensive participants was 155.68±16.97 mmHg and that during summer was 135.73±13.46 mmHg. Test of significance showed statistically significant difference in mean BP during winter and summer (p=0.0001).Seasonal variation in mean SBP was 19.95 mmHg and 11.7 mmHg in DBP among 81 HT participants with both SBP and DBP higher in winter as compared to summer.

CONCLUTION

Seasonal variation in temperature between winter and summer has significant effect on BP in all participants; more so in hypertensive group, as there is statistically significant variation in mean SBP & mean DBP during winter and summer. A significant number of participants had uncontrolled BP in winter requiring increase in dosage of anti-hypertensive medication. Higher outdoor temperature during summer is significantly associated with lower mean BP in hypertensive patients across the age groups. The reduction in BP during higher temperature needed reduction in dose of antihypertensive medications in a few patients, though not significant in number. Surprisingly, all of them were having a diuretic in prescription.

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, and no statistical association was found between BMI and systolic and diastolic difference in normotensive group.

DISCUSSION

The present study titled **"A Study of the effect of the seasonal variation on blood pressure among healthy individuals and hypertensive individuals"** was conducted in Department of Medicine in People's College of Medical Sciences & Research Centre and associated hospital, Bhopal and Govt. Medical College ; Ratlam . A total of 200 participants were registered in the study, 100 in each hypertensive and normotensive group out of which 44 were lost to follow up over a period of eighteen months. So the final analysis of data was done for 156 participants (81 hypertensive and 75 normotensive).

Alpérovitch A, Lacombe JM et al studied relationship between blood pressure and outdoor temperature in a large sample of elderly individuals in the Three-City study.Blood pressure was measured at baseline and 2-year follow-up examinations. Daily outdoor temperature measured at 11 AM was provided by the local meteorological offices. Both systolic and diastolic blood pressure values differed significantly across the 4 seasons and across the quintiles of the distribution of outdoor temperature. Systolic blood pressure decreased with increasing temperature, with an 8.0–mm Hg decrease between the lowest (<7.9°C) and the highest (≥21.2°C) temperature quintile. Intraindividual differences in blood pressure between follow-up and baseline examinations were strongly correlated with differences in outdoor temperature. The higher the temperature at follow-up compared with baseline, the greater the decrease in blood pressure.It was concluded that outdoor temperature and blood pressure are strongly correlated in the elderly, especially in those 80 years or older. During periods of extreme temperatures, a careful monitoring of blood pressure and antihypertensive treatment could contribute to reducing the consequences of blood pressure variations in the elderly.[1]

Al-Tamer YY, Al-Hayali JM etal in their study took a group of controls and patients with essential hypertension were followed up for 1 year. Four measurements at different day temperatures were performed. In each visit, blood pressure, serum total cholesterol, and high-density lipoprotein cholesterol (HDL-C) were measured. The results showed a significant inverse relationship between mean blood pressure and serum total cholesterol levels with day temperature, while a direct relationship was observed for HDL-C value. These results suggest that in areas where significant changes in day temperature and daylight duration exist at different times of the year, blood pressure, serum cholesterol, and HDL-C levels change accordingly in a cycle with higher blood pressure and serum total cholesterol and lower HDL-C values in the coldest season.[2]

An increase in blood pressure values measured during winter either in the office, at home, or at ambulatory blood pressure monitoring was consistently observed by Modesti PA . Besides potentially contributing to increase the risk for cardiovascular events during the cold season, long term blood pressure variations can influence results of clinical trials, epidemiological surveys, and require personalized management of antihypertensive medications in the single patient. Those variations are often considered as an effect of climate, due to the close correlation observed in various countries and in different settings between temperature and blood pressure among children, adults, and specially the elderly.[3]

Iwahori T et al also did work on the same and their outcomes included changes in 24-hour urinary sodium-to-potassium ratio, sodium excretion, potassium excretion, blood pressure, and body weight in both groups .Mean measurement frequency of monitoring was 2.8 times/day during the intervention. No significant reductions were observed in either blood pressure or body weight after the intervention. Providing the device to self-monitor a sodium-to-potassium ratio did not achieve the targeted reduction of the ratio in "pure self-management" settings, indicating further needs to study an effective method to enhance the synergetic effect of dietary programs and self-monitoring practice to achieve the reduction. However, we cannot deny the possibility of reducing sodium-to-potassium ratio using a self-monitoring device.[4]

Seasonal variation in blood pressure and its relationship with outdoor temperature in 10 diverse regions of China was studied by Lewington S, LiMing.Mean blood pressure varies moderately with outdoor air temperature in many Western populations. The mean difference in systolic blood pressure (SBP) between summer (June-August) and winter (December-February) was 10 mmHg overall, and was more extreme, on average, in rural than in urban areas (12 vs. 8 mmHg; p for interaction<0.0001). Above 5°C, SBP was strongly inversely associated with outdoor temperature in all ten areas studied, with 5.7 (SE 0.04) mmHg higher SBP per 10°C lower outdoor temperature. The association was stronger in older people and in those with lower body mass index. At lower temperatures there was no evidence of an association among participants who reported having home central heating.Blood pressure was strongly inversely associated with outdoor temperature in Chinese adults across a range of climatic conditions, although access to home central heating appeared to remove much of the association during the winter months. Seasonal variation in blood pressure should be considered in the clinical management of hypertension.[5]

Charach G, Rabinovich PD et al studied seasonal changes in blood pressure and frequency of related complications in elderly Israeli patients with essential hypertension.Blood pressure was measured in four seasons in 182 patients (98 men and 84 women; age range 65–91 years) treated for hypertension in our outpatient clinic. 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). Patients aged 65–75 years were unexpectedly more sensitive to winter-summer changes than older patients. There was a correlation between a large winter-summer difference in systolic blood pressure and a body mass index between 20 and 30, but there was none in lower or higher ranges. Supplementary antihypertension treatment was required during winter in 38% of these selected

patients. Complications such as myocardial infarctions and strokes occurred twice as frequently in winter than in any other season ($p < 0.0001$). It was concluded that both systolic and diastolic blood pressures were highest during winter. Hypertension complications were more frequent in winter. [6]

In present study, among hypertensive participants significant association was found between BMI and seasonal variation of systolic blood pressure in normal (p=0.0003) and overweight participants (p=0.0001) whereas no statistical association was found between BMI and seasonal variation of systolic blood pressure in underweight and obese (p=0.74 and 0.09 respectively)Sinha P, Taneja DK et al did seasonal variation in prevalence of hypertension .Blood pressure was measured in two seasons, summer and winter. Nutritional status of each individual was assessed by BMI . Overall prevalence of hypertension (SBP≥140 or DBP≥90 mm of Hg) was 1.9 times during winter compared to summer (P<0.001). Greater increase in prevalence of hypertension during winter among older females and underweight as well as normal females was observed. Significant increase in prevalence of hypertension during winter compared to summer indicates need for considering this factor while comparing prevalence reported in different studies as well as interpreting the surveillance data based on repeat surveys.[7]

Goyal A, Aslam N did a population based four-seasons study on factors affecting seasonal changes in blood pressure .They evaluated the effect of season and temperature on prevalence and epidemiology of BP in tropical climate.It was a longitudinal cross sectional survey of rural and urban subjects in their native surroundings. BP was measured in four different seasons in same subjects. Mean BP, both systolic and diastolic were significantly higher in winter season as compared to summer season. This increase in BP was more marked in rural areas and elderly subjects. Prevalence of hypertension was significantly higher during winter (23.72%) than in summer (10.12%).BP increases significantly during winter season as compared to summer season. Increase is more marked in rural areas and elderly subjects.[8]

Abayomi EJ studied The relationship between body mass and blood pressure in diverse populations .Kristal-Boneh E worked on the association of calcitriol and blood pressure in normotensive men. They concluded that elderly persons may be particularly susceptible to temperature-related variations in blood pressure. The baroreflex, which is one of the mechanisms of blood pressure regulation, is modified in elderly subjects, and it has been hypothesized that disorders of baroreflex control and enhanced vasoreactivity could contribute to the aging-associated increase in cardiovascular morbidity.[9,10]

Funding : No funding required
Conflict of interest: No conflict of interest
Ethical approval : Taken

WHAT THIS STUDY ADD TO EXISTING KNOWLEDGE :

1. All patients of hypertension should be sensitized to have regular monitoring of BP and follow-ups for assessing control of BP and titration of anti-hypertensive medications (if needed) with change of season from summer to winter and vice versa.
2. Increase in BP in winters may require increase in antihypertensive medication dose, which may need to be readjusted with change of season.
3. Decrease in BP in summer may require a need to reassess the control of BP and consider to decrease dosage of antihypertensive drugs in some cases.
4. Caution must be taken in prescribing antihypertensive medication to elderly patients, especially diuretics in the summers when people have significant insensible water loss via sweating.

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