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Seasonal Variation in Arterial Blood Pressure.

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ABSTRACT

Background: There is need to evaluate influence of weather changes on blood pressure in human population that has often been ignored in clinical practice guidelines. Objectives: Present study was planned to find the seasonal variation of blood pressure. **Methods:** Seasonal variation in blood pressure was examined in 1081 participants of age 18 years and over from both genders, 540 from rural and 541 from urban practice area of Department of Community Medicine of tertiary care teaching hospital of Ludhiana. Information was obtained on demographic and socioeconomic characteristics and socio-economic status followed by clinical examination. Anthropometric measurements included weight, height, waist circumference, hip circumference, waist and hip ratio, Body Mass Index. Blood pressure was recorded and classified based on JNC VII criteria. Data was obtained on four different seasons (winter, summer, monsoon and post-monsoon) as defined by Indian meteorological department. **Results:** Present study showed that there is significant increase in the blood pressure in study population during winter and significant fall in summer in both systolic (SBP) and diastolic blood pressures (DBP) irrespective of age, sex, socioeconomic status, occupation. The variation in SBP between summer and winter season was maintained across all the age groups except in elderly where maximal difference was observed in monsoon - summer seasons. Mean SBP and DBP were higher in 41 to 50 years and more than 60 year age group; females have a higher increase in both mean SBP and DBP. Advancement in age and females gender confirmed more significant changes in blood pressure across ambient temperatures. **Conclusion:** Our study showed that climatic changes influence the blood pressure recordings and should also be considered for management of hypertension.

Keywords: Hypertension, season, Temperature.

INTRODUCTION

Blood pressure is continuously distributed variable in populations as one of the most common global health problem. The risks imposed by hypertension are indisputable and confirmed by large scale epidemiological observations.[1,2] Amongst the various modifiable predisposing risk factors identified in association with hypertension include obesity, insulin resistance, salt intake, alcohol abuse, physical inactivity, environmental stress. Some other factors related to hypertension include arterial stiffness, noise, temperature and humidity. The influence of temperature changes on blood pressure has often disregarded despite extensive literature.

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Indian data on seasonal variation of blood pressure is very limited. A proximal link in the chain is probably a failure of autonomic control of body temperature leading some non-compensatory mechanisms.[3] Literature reported seasonal variations in different age groups. However, both systolic and diastolic blood pressures were highest during winter; also slightly greater fluctuations were found in the hypertensive elderly; complications from hypertension were more common in winter among the elderly.[4] Seasonal variation in blood pressure (BP), a usual tendency of both systolic (SBP) and diastolic BP (DBP) to rise during winter in hypertensive patients, may be related to the higher cardiovascular mortality in winter. However, it is not yet clear what factors are relevant to the seasonal BP changes though a feasible link between arterial stiffness and seasonal BP variation was hypothesized that may partly explain higher cardiovascular risk in patients with increased arterial stiffness.[5] Hypertension is an important public-health challenge worldwide. Prevention, detection, treatment, and control of this condition should receive high priority.[6] In the above scenario the present study was undertaken to find out seasonal variation of blood pressure in both rural and urban populations of Ludhiana in North India where marked differences in the temperatures seen in different seasons.

MATERIALS AND METHODS

This was an observational one year prospective population based study carried out in Ludhiana district of Punjab in North India to determine the relationship between the different seasons and blood pressure. Seasonal variations in blood pressure was examined among randomly recruited 1081 participants of age 18 years and over from both genders, 540 from rural and 541 from urban and rural field practice area of Department of Community Medicine of tertiary care teaching

hospital of Ludhiana. This site seems ideal for conducting this study as this place has extremes of temperature variations i.e. subzero or very low in winter to 48° C in summers.

Inclusion Criteria:

a. Consenting participants of both gender with age ≥18 years
b. From urban and rural field practice area of Department of Community Medicine of tertiary care teaching hospital of Ludhiana.

Exclusion Criteria:

a. Non-consenting participants with age <18 years

Data Collection Procedure:

Each participant was individually counselled prior to participation in the study that no potential risk was involved in their participation as they will only have to allow routine clinical procedures during this research work and nothing will be administered in their body. They were also ensured that each of them had full autonomy to leave the study at any point of time. Each participant was asked to provide informed consent in the prescribed form in his or her mother tongue prepared by us as part of research protocol.

After obtaining written informed consent, face-to-face interviews and baseline clinical examinations and measurements were performed. Information was obtained on demographic and socioeconomic characteristics including age, gender, education, occupation and socioeconomic status. Interview tried to unearth systemic complaints, comorbid conditions, history of detailed treatment of morbidities and co-morbidities. Data on past and present alcohol and tobacco consumption were collected followed by classification as current, former or never drinkers/ smokers.

After detailed history, thorough clinical examination along with anthropometric evaluation was carried out. Anthropometric measurements included weight, height, waist circumference, hip circumference, waist and hip ratio, BMI measurements using standardized techniques.

Waist circumference was measured between lower limit of rib cage and the iliac crest in centimetres with subject standing, using flexible non distensible tape.

Height was measured with non-stretchable tape to nearest centimeter. Subjects were requested to stand upright without shoes with their back against the wall, heels together and eyes directed forward.

Weight was measured with traditional spring balance that was kept on horizontal surface. Subjects were asked to wear light clothing and weight was recorded to nearest half kilogram.

Waist circumference was measured using a non-stretchable measuring tape. The subjects were asked to stand erect in a relaxed position with both the feet together on a flat surface; one layer of clothing was accepted. Waist girth was measured as the smallest horizontal girth between the costal margin and the iliac crest at minimal respiration.

Hip circumference was taken as the greatest circumference at the level of greater trochanters (the widest portion of the hip) on both sides; measurements were made to the nearest centimeters.

Waist and Hip ratio (WHR) was calculated by dividing the waist circumference (cm) by the hip circumference (cm).

Body mass index (BMI) was calculated by using the formula: weight (kg) / height (m) ^{2}

Blood pressure measurements

Blood pressure devices were regularly calibrated. Blood pressure measurement was done in sitting position in right arm with no tight cloths to the nearest 2 mmHg using the mercury column sphygmomanometer. Two readings were taken five minutes apart and the mean of both measures was taken for analysis. Systolic BP was recorded at the appearance of the first Korotkoff's sound, and the palpatory method was used to check auscultatory systolic readings the diastolic BP was recorded at disappearance of Korotkoff's sounds. It was assured that subjects were sitting in comfortable settings with no consumption of caffeine in preceding one hour or smoking in preceding 15 minutes.

Definition of hypertension

Subjects with a mean SBP greater than or equal to 140 mmHg or a mean diastole BP greater than or equal to 90 mmHg were considered as having hypertension (JNC VII criteria).[7]

Meteorological Data

Data about temperature, relative humidity and atmospheric pressure was obtained from the local agency of National Weather Service Punjab Agriculture University (PAU), Ludhiana. Data was obtained in four different seasons as defined by Indian Meteorological Department.

- winter season from January to March
- summer season, from March to June
- Monsoon or rainy season, from June to September
- Post-monsoon season, from October to December

The variables were assessed as maximal, minimal and mean temperatures, humidity and atmosphere pressure daily. The monthly means of the daily average of all these measurements were used for the study.

Statistical Analysis

The data collected in respect of various variables was statistically analysed. Mean and standard deviation were computed. Variance analysis was

used to compare the distribution of baseline measures of SBP and DBP across the four seasons. This was analyzed in the whole sample and in the different strata based on age, gender, BMI, smoking habits and alcohol consumption. The relationship between blood pressure, humidity and atmospheric pressure were analyzed in the same way. The comparison between groups was done by 't'-test, 'z'-test or ANOVA wherever applicable. To reduce the risk of biohazards, all the precautions were undertaken following standard operative procedure. The procedure was well tolerated by all the participants with no reported medical complaint. The time required did not exceed 15 minutes per participant for acquisition of data that included the counselling times. The data were strictly kept confidential and were not disclosed for the assessment, management or intervention.

RESULTS

The present study was carried out to find the seasonal variation of blood pressure in general population of both rural and urban areas of district Ludhiana, Punjab. A total number of 1081 subjects were included for this study, 540 from rural population and 541 from the urban population. The baseline demographics of the subjects studied in both the rural and urban population. In a total of 1081 subjects interviewed 248(22.94 %) subjects were in the age group of less than 30 years ,335(30.80 %) in the 31-40 years, 206(19.05%) in 41-50 years, 142(13.13 %) in 51-60 years and 150(13.87 %) were in the age group of > 60 years. There were 703(65.03 %) male subjects and 377(34.87%) female subjects. In the urban population a significant number of subjects (n=404, 74.4%) were educated up to graduation level or above in comparison to the rural area (n=36, 6.6%). The number of illiterate subjects in rural population were 169(31.2%) as compared to 12(2.2%) in the urban area. As per the occupation, majority of the subjects (n=350, 64.7%) were moderate workers in the urban area and majority were light workers (n=518, 95.7%) in the rural population. It was also observed that 105 (19.4%) and 59 (10.9%) of the subjects were alcoholic in the rural and urban areas respectively. Smokers were 48(8.8%) and 8(1.5%) in the rural and urban population respectively. Socioeconomic status was upper- middle in majority of the urban subjects (n=183, 33.82%) and low (n=247, 45.74%) in the rural area. [Table 1].

Table 1: Baseline demographics of reference population.

Variables	Rural	Urban	Total
Age (years)			
Less than 30	119(22.03)	129(23.84)	248(22.94)
31-40	116(21.48)	219(40.48)	335(30.98)
41-50	99(18.33)	107(19.77)	206(19.05)
51-60	64(11.85)	78(14.41)	142(13.13)
60 and above	142(26.29)	8(1.47)	150(13.87)
Sex			
Male	359(66.4)	344(63.6)	703(65.03)
Female	180(33.5)	197(36.4)	377(34.87)
Education			
Primary	102(18.8)	12(2.2)	114(10.54)
Middle	61(11.2)	26(4.78)	87(8.04)
Senior secondary	172(31.8)	87(16.1)	259(23.59)
Graduate or above	36(6.6)	404(74.7)	440(40.70)
Illiterate	169(31.2)	12(2.2)	181(16.74)
Occupation			
Heavy workers	1(0.2)	99(18.3)	100(9.25)
Moderate workers	22(4.0)	350(64.7)	372(34.41)
Light workers	518(95.7)	91(16.82)	609(56.33)
Socioeconomic status			
Low	247(45.74)	82(15.15)	329(30.43)
Middle	231(42.77)	176(32.53)	407(37.65)
Poor	7(1.29)	65(12.01)	72(6.66)
Upper	17(3.14)	35(6.46)	52(4.81)
Upper middle	38(7.03)	183(33.82)	221(20.44)
Alcohol consumption			
Yes	105(19.4)	59(10.9)	164(15.17)
No	436(80.6)	481(88.9)	917(84.82)
Smoking			
Yes	48(8.8)	8(1.5)	56(5.18)
No	483(89.27)	532(98.3)	1015(9.89)

The meteorological information on season wise distribution of environmental variables was obtained from the meteorological department, Government of India during the periods of the study showed a mean temperature during study period was 31.2 C, 26.1 C, 14.8C, 26.15 C, during monsoon, post-monsoon, winter, summer seasons respectively. Mean humidity during the study period was 54.96%, 72.2%, 71.5%, 55.5% during monsoon, post-monsoon, winter and summer seasons respectively. Similarly mean atmospheric pressure during study period was 956.60 K Pa, 985 K Pa, 980.01 K Pa, 986.15 K Pa during monsoon, post-monsoon. winter, summer seasons respectively [Table 2].

Table 2: Meteorological parameters in four seasons during the study period.

Season	Mean temperature(C)	Mean humidity (%)	Mean Pressure(K Pa)
May 2009	31.2	40	916.12
June 2009	32.6	45	977.89
July 2009	29.8	79.9	975.81
Sep 2009	28.2	77	981.97
Oct 2009	24.0	67.4	978.06
Dec 2009	13.8	71	982.06
Feb 2010	15.8	72	990.25
Mar 2010	22.9	65	986.91
Apr 2010	29.4	46	983.10

Mean Systolic blood pressure maximally decreased from 131.70 +20.72 mm Hg in winter to 122.66 + 17.56 mm Hg in summer season. The difference of blood pressure between summer and winter was statistically significant (p=0.000).Similarly the trend of decline in diastolic blood pressures maximal from winter season to summer season (p=0.000). It decreased by 5.63 mmHg from 83.28 + 11.52 to 77.65+10.97 mm Hg.

The prevalence of stage 1 and stage 2 hypertension based on systolic blood pressure was maximal in winter season. It was also observed that 414 (38.29%) subjects were Pre- hypertensive in monsoon season, which increased to 452 (41.81%) subjects in winter season and prevalence of isolated systolic pre-hypertensive subjects increased to 425 (39.31%) subjects in summer season. Out of a total of 1081 subjects, 191 (12.66%) were stage 1 hypertensive in monsoon season and number increased to 213 (19.70%) in winter season. There were 86 subjects (7.94%) in stage 2 isolated hypertension group which increased to 99 subjects (9.15%) in winter season. The prevalence of stage1 and stage 2 hypertension based on diastolic blood pressure was maximum during the winter and monsoon seasons respectively. The prevalence of isolated stage 1 and stage 2 diastolic hypertension was lowest in summer season.

It was observed that 262 subjects (24.23%) were normotensive in monsoon season which decreased to 178 (16.46%) in winter season. Out of a total of 1081 subjects, 262 (24.23%) were in stage 1 hypertension in monsoon season and 282(26.08%) in winter season. There were 113 (10.45%) in stage 2 hypertension in monsoon season and decreased to 83 (7.67%) subjects [Table 3].

Table 3: Variation of cardiovascular parameters among participants in four seasons.

Season	PR(per min)	Systolic blood pressure	Diastolic blood pressure	
Monsoon	78.37 ± 7.63	128.00 ± 20.33	83.70 ± 11.59	
Post monsoon	78.78 ± 8.24	127.71 ± 16.29	81.82 ± 11.10	
winter	79.74 ± 8.89	131.70 ± 20.72	83.28 ± 11.52	
summer	80.62 ± 8.47	122.66 ± 17.56	77.65 ± 10.97	
Isolated systolic hypertension				
Season	**Normotensive**	**Pre-hypertension**	**Stage 1**	**Stage 2**
Monsoon	390(36.0)	414(38.29)	191(12.66)	86(7.94)
Post monsoon	363(33.58)	517(47.91)	164(15.17)	37(3.42)
winter	317(29.32)	452(41.81)	213(19.70)	99(9.15)
summer	500(46.25)	425(39.31)	121(11.19)	35(3.25)
Isolated diastolic hypertension				
Season	**Normotensive**	**Pre-hypertension**	**Stage 1**	**Stage 2**
Monsoon	444 (41.07)	262 (24.23)	262(24.23)	113(10.45)
Post-monsoon	542 (50.13)	241 (22.29)	216(19.98)	82 (7.58)
winter	538 (49.76)	178 (16.46)	282(26.08)	83 (7.67)
summer	749 (69.28)	134 (12.39)	169(15.63)	29 (2.68)

DISCUSSION

Researchers have reported that blood pressure generally is higher in the winter and lower in the summer because low temperatures cause our blood vessels to narrow increasing peripheral resistance. In addition to cold weather, blood pressure may also be affected by a sudden change in weather patterns,

such as a weather front or a storm or blood vessels may react to abrupt changes in humidity, atmospheric pressure, cloud cover or wind in much the same way it reacts to cold. These weather-related variations in blood pressure are more commonly noted in elderly ages.[8]

A study reported association between seasonal BP variations and some components of quality-of-life (QoL) indicators. The higher QoL indicators reflecting the social support of hypertensive patients decreased a seasonal variability in their BP: for SBP during morning, evening, and night hours and throughout the working day and for diastolic BP during daytime and morning hours.[9]

Both environmental factors and genetic factors may contribute to regional and racial variation of blood pressure and hypertension prevalence. Many studies have shown that both systolic and diastolic blood pressures increase in low ambient temperature. It may be due to sympathetic stimulation and increase in levels of catecholamines in response to cold. Reverse changes were observed during summer season. Similarly, complications related to increased blood pressure such as stroke were more during winter season. This inverse correlation has been described in both normotensive and hypertensive population as well as in patients with end stage renal disease. As human beings are warm blooded (homeothermic), a group of reflex responses exist which keep the core temperature in a narrow range in spite of marked variation of environmental temperature. The various reflex mechanisms operating in the two seasons i.e. winter and summer and their effect on blood pressure has been described :[10]

Effect of winter season on blood pressure

Blood pressure is expected to rise in winter season by following mechanisms

- Shivering
- Increased food intake
- Increased voluntary activity
- Increased secretion of epinephrine and nor-epinephrine

Due to Increase cardiac output

- Cutaneous vasoconstriction
- Curling up

Increased peripheral resistance

Effect of summer seasons on blood pressure

- Cutaneous vasodilation
- Sweating
- Increased respiration
- Anorexia

Verdon et al noted the characteristics and determining factors of seasonal variations of the blood pressure (BP) on normal subjects and chronic stable chronically all patients, most of them were ambulatory. In normal subjects, the BP decreased from June to reach its lowest value in August to return to the winter values from October. The summer decrease was greater in women than in men; increased with age but disappeared after 70-80 years of age of life. Blood pressure lowering drugs increased this effect and the association of several drugs had an additive effect. The very elderly patients on antihypertensive therapy showed a marked decrease in BP during the summer, especially in the upright position. The summer decrease in BP is important for the management of elderly patients with hypertension or cardiac failure. It may favour the risk of orthostatic hypotension and increase of malaise.[11]

Ahuja et al in their study has shown that BP rises in December, January of winter season and BP decreases in June, July, in summer season. [12]

Charach et al evaluated the seasonal variation in blood pressure and the variables of age, gender, body mass index and related complications in elderly Israeli patients with essential hypertension in a prospective study. It was noted that in four different seasons the systolic and diastolic blood were highest during the winter season with more hypertension related complications compared to summer; no significant seasonal differences between spring and autumn; age group 65-75 years were unexpectedly more sensitive to winter-summer changes. A correlation between a large winter-summer difference in systolic blood pressure and a body mass index between 20 and 30 was noted. Supplementary antihypertensive 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.[3]

Study conducted by Youn et al showed that arterial stiffness was related to seasonal variation of blood pressure in hypertensive patients. Seasonal BP profiles over at least 2 years were studied along with arterial stiffness and clinical variables (age, gender, smoking and duration of hypertension, anti-hypertensive medications and body mass index). Both SBP and DBP were significantly higher during winter compared with three other seasons. There were no significant seasonal differences among spring, summer and autumn. Pulse wave velocity (PWV) was correlated with significant predictor for winter-summer SBP changes. Age, which was correlated with PWV significantly, was not significantly related to the seasonal changes in BP. No other clinical variables had significant correlation with seasonal BP changes.[5] Greater increase in systolic and diastolic blood pressure during winter among older age groups has been reported in other studies.[13]

Brennan et al in 1982 conducted a study among 17,000 men and women regarding the effect of seasonal variation on blood pressure. They found that both systolic and diastolic blood pressure are elevated in winter and reduced in summer. Effect is more marked in old age, thin and in females than in young males.[14]

Study conducted by Tozawa et al on dialysis patients from hemodynamic patients in Japan found that atmospheric temperature and relative humidity are strongly correlated with SBP and DBP. Blood pressure readings were more during winter seasons. The relation of ambient temperature (AMT) and relative humidity to SBP, DBP, body weight, and body weight gain between dialysis sessions (DeltaBW) was examined in hemodialysis patients by Fourier analysis. The cross-correlation coefficient showed that monthly mean AMT and SBP, DBP, BW, and DeltaBW were correlated with a lag time of 5 or 6 months. In analyzing subgroups of patients according to the presence or absence of antihypertensive medications, a seasonal change was observed in the SBP and DBP of patients not being treated with anti-hypertensive, and in the DBP of patients taking antihypertensive medications, but not in the SBP of patients taking antihypertensive medications. Seasonal variations in SBP, DBP, BW and DeltaBW were evident. AMT and the relative humidity correlated strongly with SBP, DBP, BW and DeltaBW.[15]

Studies have shown that there is a seasonal variation in adrenocortical function. Urinary estimation of 17 hydroxysteroids shows an increased level in winter and low level in summer.[16] This variations maintain a linear relation with the temperature. This correspondingly contributes to change of blood pressure.[17]

Bodnar et al studied on pregnant females to assess seasonal variability in antenatal blood pressure (BP) to peak in winter and reached a rock bottom in summer. After stratifying by overweight status, BP showed strong seasonal variability among lean women, whereas there were no seasonal trends among overweight women. Environmental factors may regulate gestational BP and may be relevant to seasonality of hypertensive disorders of pregnancy because of the fact that increase in blood pressure in winter will shift the proportion of the subjects from normotensive to the hypertensive category.[18]

Study conducted in India has shown that on exposure to hot environment both systolic and diastolic blood pressures are reduced. The issue is also important for surveillance as data collected in different seasons may not find true trends.[19]

Significant increase in SBP and DBP during winter may be for several reasons viz. external temperature, physical activity, seasonal variation in noradrenalin, catecholamine and vasopressin, vitamin D, and serum cholesterol among others. However, the evidence suggests that a number of simple precautions to reduce the risk of hypertension in winter could be taken including adequate indoor heating, wearing protective clothing, especially for elderly patients. Attempts should also be made to ensure that our lifestyles, in relation to diet, regular exercise, are at least as healthy in winter as they are in summer.[20]

The strengths of the study were that seasonal variation in the prevalence of hypertension has not been studied much in India. Careful analysis of the data indicated that the variations in blood pressure attributable to the month of the year are at least as significant as those due to physiological variables. Limitation of the study was that we had done this study only for one calendar year; instead, a repeated study over years could have brought more results that are valid. In the future directions of the next phase of study we wish to include biochemical parameters to explore reasons of fluctuation of arterial blood pressure over seasons in the multicentric study with robust sample size.

CONCLUSION

To sum up, the study has been conducted in an area where wider seasonal differences are observed in temperatures and found a positive correlation with arterial blood pressure. During plan of treatment, seasonal variation of blood pressure should also be considered. This indicates how estimates of the prevalence of hypertension may be substantially biased if the seasonal pattern in blood pressure is not taken into account in epidemiological surveys; in addition it should be recognized as important in daily clinical work- especially in those patients who are in need of antihypertensive treatment.

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