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RESEARCH ARTICLE

Effect of cold pressor test on blood pressure in normotensives and hypertensives

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ABSTRACT

Background: Hypertension is an important worldwide public health challenge because of its high frequency and concomitant risks of cardiovascular and kidney disease. The cold pressor test (CPT) as a tool to measure cardiovascular reactivity, specifically blood pressure (BP) changes, in response to stress. **Aims and Objectives:** The aim of the study is to see the effect CPT on hypertensives and age and gender-matched normotensive (NT) individuals. **Materials and Methods:** The study was carried out in 60 individuals aged between 30 and 60 years consisting of 30 known cases of hypertension and 30 age and gender-matched normotensive (NT) from outpatient department of Mc Gann Hospital, Shimoga. Keeping CPT as the stimulus, the response was recorded in all the individuals and they were divided into normoreactors and hyperreactors. Statistical analysis was done using SPSS 21. **Results:** Hypertensives showed a significantly higher increase in systolic and diastolic BP and greater number of hyperreactors ($P > 0.01$) when compared to the NT for the CPT. **Conclusion:** CPT has been used for the diagnosis of cardiovascular reactivity in NT and hypertensive individuals and the responses to CPT may help identify NT candidates at future risk of suffering from hypertensive disease. It also helps implement early preventive measures to halt the progression to sustained hypertension developing at a future date.

KEY WORDS: Cold Pressor Test; Hypertensives; Normotensives

INTRODUCTION

Hypertension is an important worldwide public health challenge because of its high frequency and concomitant risks of cardiovascular and kidney disease. It has been identified as the leading risk factor for mortality and is ranked third as a cause of disability-adjusted life years. The disease is a silent threat to the health of people worldwide. Hypertension has been reported to be generally associated with sympathetic over activity.[1]

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The regulation of blood pressure (BP) involves the interaction of various systems and factors. Hypertensive diseases could result from a variety of dysfunctions occurring at any point in this complex pressure regulatory mechanism. Among the various systems and factors which have been implicated in the physiopathology of various forms of hypertension, the sympathetic nervous system has been the subject of renewed interest in recent years.[2]

In 1932, Hines and Brown introduced the cold pressor test (CPT) as a tool to measure cardiovascular reactivity, specifically BP changes, in response to stress. The CPT stimulus involves both a cold and pain component, which induces a thermoregulatory reflex and global sympathetic activation, producing several physiological responses, including vasoconstriction, and BP elevation. Reactibility of the BP is an index of vasomotor tonus.[3]

The CPT measures the response of BP to the stimulus of external cold. The CPT, in which the response of BP to the stimulus of external cold is measured, has been used to identify hyperreactor individuals who might develop hypertension. Hence, the cold pressure test study examines its effectiveness as a predictor of hypertension. Therefore, it helps detect the latent stages of hypertension so that early preventive measures can be implemented to reduce morbidity and mortality caused by hypertension and its complications.

Studies show that hypertensive persons show greater liability of BP under various forms of stress compared to NT persons.[4] Hence, this study was undertaken to see the effect of BP using CPT on hypertensives and compare the same with age and gender-matched NT individuals.

Aims and Objectives

The aim of the study is to study the effect of CPT on BP in hypertensive individuals and compare with age and gender-matched NT s (NT).

MATERIALS AND METHODS

The study was carried out among 60 individuals aged between 30 and 60 years which included 30 diagnosed cases of essential hypertension and 30 age and gender-matched NT attending the outpatient department of McGann Hospital, Shimoga. Known cases of diabetes, Ischemic heart disease, cervical rib, and those individuals with any history of chronic illness or drug intake that may have a potential affect on the cardiovascular parameters were excluded from the study.

Institutional Ethical Committee clearance was obtained. Details of the study protocol were explained to the individuals who volunteered for the study. Informed consent was obtained. An overview of the complete test was given to all individuals before starting the procedure. All the recording was done by the same investigator. Instruments were calibrated before the test was performed.

- Mercury sphygmomanometer was used to record the BP in the right arm in the seated position. 10 min rest was given before measuring the BP to free the individual of anxiety. The systolic and the diastolic BP will be marked by 1st and the 4th Korotkoff sounds.
- BP was recorded before performing the Cold Pressor Test. Individuals were asked to dip their left hand up to the level of their wrist in a container having water at 4°C for a duration of 1 minute. During the CPT, a second recording of BP was taken.
- Based on the reactivity to CPT the individuals were divided into two groups, i.e., normoreactors and hyperreactors based on the work of Hines.[5]
- Individuals with rise of systolic BP of more than 22 mm of Hg and/or rise of diastolic BP by 18 mm of Hg were grouped as hyperreactors. Only individuals with systolic and diastolic BPs rise not more than 22 mm of hg and 18 mm of hg, respectively, came under the normoreactors.[6]
- Keeping CPT as the stimulus, the response was recorded in all the individuals. Then, the results of the CPT were evaluated and checked for any variation between NT and hypertensives.

Statistical analysis was done using the SPSS software version 21 by unpaired *t*-test and Chi-square test and $P < 0.05$ was considered significant.

RESULTS

The individuals aged between 30 and 60 years were divided into two groups - NT and hypertensives. Anthropometric parameters showed no significant difference among both groups (Table 1). Systolic and Diastolic BP were measured in the beginning of the test after 10 min of rest using a sphygmomanometer. Systolic and Diastolic BP among hypertensives were significantly higher compared to the NT with $P < 0.01$.

The mean ± standard deviation (SD) value of systolic BP after the CPT among the hypertensives was found to be 159.74 ± 13.96 and significantly higher ($P < 0.0001$) compared to NT which was 124 ± 11.42. The mean ± SD value of diastolic BP after the CPT among the hypertensives was found to be 99.32 ± 11.24 and significantly higher ($P = 0.0002$) compared to NT which was 88.86 ± 8.90 (Table 2).

The mean ± SD value of difference of systolic BP after the CPT among the hypertensives was found to be 25 ± 8.74 and significantly higher ($P < 0.0001$) compared to NT which was 14.28 ± 7.86. The mean ± SD value of difference of diastolic BP after the CPT among the hypertensives was found to be 18 ± 7.63 and significantly higher ($P = 0.005$) compared to NT which was 12.64 ± 6.54 (Figure 1). The raise in systolic as well as diastolic BP was significantly higher in hypertensives compared to age- and gender-matched NT.

The individuals were further divided into normoreactors and hyperreactors. Normoreactors included individuals in whom difference in systolic BP was not more than 22 mm of Hg and difference in diastolic BP was not more than 18 mm of Hg after the CPT. Hyperreactors included individuals in whom difference in systolic BP was more than 22 mm of Hg and difference in diastolic BP was more than 18 mm of Hg after the CPT.

Among NT, 11 were hyperreactors whereas among hypertensives around 21 were hyperreactors (Table 3 and Figure 2). Thus, the study shows significantly ($P = 0.01$) more number of hyperreactors among hypertensive individuals compared to the NT individuals.

Table 1: Anthropometric parameters of normotensives and hypertensives

Parameter	Normotensives	Hypertensives	*t* value	*P* value	Significance
Age (years)	45.72±8.65	48.53±7.92	1.31	0.195	NS
BMI (kg/m^2)	23.21±3.52	24.86±3.10	1.9	0.06	NS

BMI: Body mass index, NS: Not significant

Table 2: Comparison of various parameters in normotensives and hypertensives

Parameters	Mean±SD		*t* value	*P* value	Significance
	Normotensives	Hypertensive			
SBP (mm of Hg)	110.22±7.83	134±8.69	11.13	0.0001	HS
DBP (mm of Hg)	76±8.72	81±6.42	2.53	0.01	S
SBP after immersion (mm of Hg)	124±11.42	159.74±13.96	10.85	<0.0001	HS
DBP after immersion (mm of Hg)	88.86±8.90	99.32±11.24	3.99	0.0002	HS
Difference of SBP (mm of Hg)	14.28±7.86	25±8.74	4.99	<0.0001	HS
Difference of DBP (mm of Hg)	12.64±6.54	18±7.63	2.92	0.005	HS

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation, S: Significant, HS: Highly significant

Table 3: Percentage of normoreactors and hyperreactors among normotensives and hypertensives

Group	Number of individuals	*n* (%)		χ^2	*P* value
		Hyperreactors	Normoreactors		
Normotensives	30	11 (36.7)	19 (63.3)	5.42	0.01 (S)
Hypertensives	30	21 (70)	09 (30)		

S: Significant

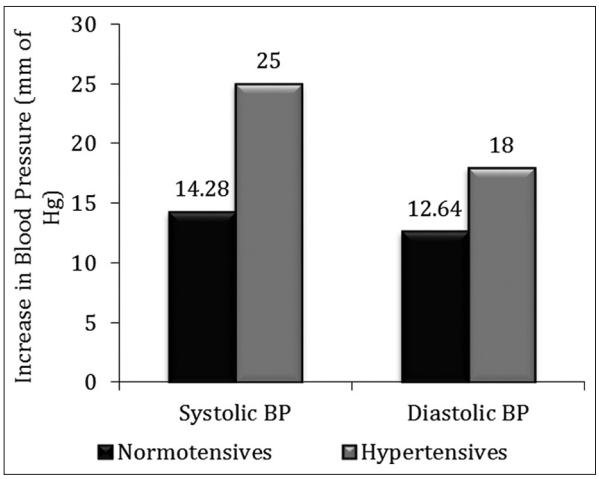

Figure 1: Response to cold pressor test: Normotensives and hypertensives

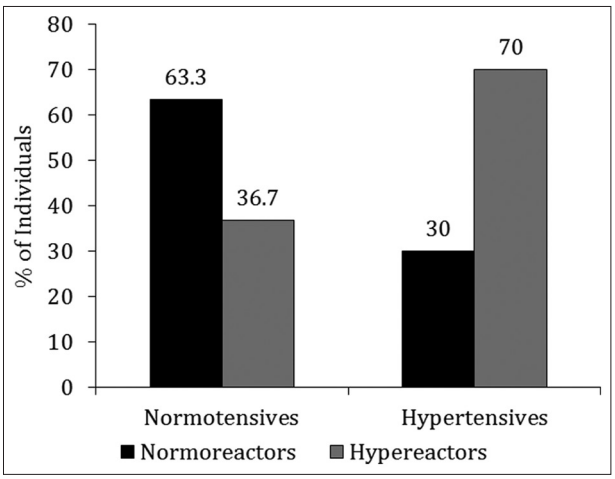

Figure 2: Comparison of hyperreactors and normoreactors in normotensives and hypertensives

DISCUSSION

The majority of individuals with hypertension and some with usually normal BP manifest unusual lability and marked reactions of BP to various internal and external stimuli. This suggests that the mechanism for regulating BP which is possessed by these individuals is hyperreactive. The CPT is a satisfactory method of determining the reactivity of the BP. The test consists in measuring the reaction of the BP to a standard cold stimulus.[7]

Shapiro et al. in their study entitled "patterns of pressor response to noxious stimuli in normal, hypertensive, and diabetic individual" on 33 NT and 35 hypertensives showed that hypertensive patients are more responsive than NT individuals to simple psychological stimuli as well as to the CPT.[8]

Bentos and Safar in their study entitled "response to the CPT in NT and hypertensive patients" assessed 49 NT and 73 hypertensives a positive correlation was found in hormone

therapy (HT) patients between basal levels of active renin (AR) in the upright position and mean BP (MBP) changes during CPT ($P < 0.001$). Mean plasma AR was 24.2 ± 3.5 pg/mL in nonresponders versus 37.5 ± 2.9 pg/mL responders ($P < 0.001$). In HT, but not in NT, patients, BP changes were associated with a simultaneous increase in heart rate (HR) ($P < 0.01$ between ΔMBP and ΔHR). These results suggested that BP elevation during CPT is a very common reaction in young NT individuals, especially in those that have the lowest MBP. In addition, in hypertensive patients the BP elevation during CPT reflects an age-independent sympathetic over activity.[9]

Schater and Joseph in their study entitled "pain, fear, and anger in hypertensives and NT: A psychophysiological study" conducted a study on 18 hypertensives and 15 NT showed significantly greater rises in BP during pain (assessed by CPT), fear, and anger when compared to NT.[10]

Pai et al. in their study entitled "effects of CPT on BP and HR variability in the wards of hypertensive parents" examined the effect of cold pressure stress on BP and HR variability in the wards of hypertensive parents. The study included 67 individuals, 30 with parental history of hypertension and 37 with had NT parents. CPT was done. BP was measured and electrocardiography was recorded during normal breathing, deep breathing, and CPT. The data obtained were analyzed using student's *t*-test and by Mann–Whitney U test and $P < 0.05$ was considered significant. Cold pressure stress showed a significant increase in systolic and diastolic BP in study group with respect to control group ($P < 0.01$).[11]

Hines and Brown in their study "reaction of BP of 400 school children to a standard stimulus" have shown that hypertensive persons show greater lability of BP under various forms of stress than NT persons and NT "hyperreactors" to the CPT are more likely to have a positive family history of hypertension than NT persons who are less reactive.[5]

Thacker in his study titled "a comparative study of normal and abnormal BPs among university students, including CPT" measured the BP reactions to a cold stimulus in university students with high and normal BP. With the application of the CPT, it was noted that maximum increase in systolic and diastolic BP in hypertensive group than in the control group. There was a far greater difference between the usual systolic BP and the basal BP in the hypertensive group than in the normal group. This criterion is a definite aid in discovering hyper reactors, especially when it is confirmed by the cold test.[12]

In the present study, hypertensives showed an increase rise in systolic and diastolic BP compared to the NT. Hyperreactors were present in both NT and hypertensives; however, there were more hyperreactors among the hypertensives. Hyper responsiveness may represent one pathogenic mechanism in the development of essential hypertension, be a marker for a central defect in the autonomic control of the cardiovascular system, or reflect early changes in arterial compliance of future hypertensive individuals. One intriguing mechanism that has been proposed is that pressor hyperreactivity is a manifestation of a widespread basic membrane transport disorder that disrupts cellular cation homeostasis. Sodium lithium transport abnormalities have been observed in blood cell membranes of patients with essential hypertension.[11]

Limitations

Prospective studies are required to examine the putative link between the NT hyperreactors to exactly establish a link that hyper responsiveness is a predictor of essential hypertension.

CONCLUSION

Elevated Systolic and diastolic BP in response to CPT and significantly higher number of hyperreactors were observed in the hypertensives. Thus, the latent period of vascular hyperreactivity can be detected earlier by applying CPT to implement early preventive measures to halt the progression to sustained hypertension developing at a future date. Responses to CPT may also help identify NT candidates at a future risk of suffering from hypertension. The regular use of this test can be recommended in high-risk individuals for screening of hypertension. However, follow-up studies are needed to establish CPT as a predictor of hypertension.

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