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Full Length Research Article

EFFECTS OF PHYSICAL STRESS TEST ON BLOOD PRESSURE, HEART RATE, RATE-PRESSURE-PRODUCT AND DOUBLE PRODUCT IN NORMOTENSIVE SUBJECTS WITH OR WITHOUT FAMILY HISTORY OF HYPERTENSION

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ABSTRACT

Background: Cardiovascular diseases (CVD) are the number one killer of modern humankind. And in this, hypertension is a noncommunicable, major silent disease. Rate pressure product (RPP) and Double product (DoP) is an important hemodynamic parameter which reflects myocardial oxygen demand and workload. It varies with exercise.
Objective: To find out possible alteration in BP, HR, RPP and DoP in normotensive subjects with or without family history of hypertension.
Materials and Methods: The study was conducted on total 120 participants, 60 in control and 60 in test group. Cardiovascular response to stress was determined by Harvard step test. Heart rate (HR), blood pressure, RPP and DoP response to exercise were measured in supine position before exercise and at 1, 2, 3, 4, 5, 7 and 10 minutes after the exercise. The results were expressed as Mean ± SD and analyzed using Independent t- test (unpaired t-test) for comparison between the control group and the test group and one way ANOVA test
Results: The "P" value < 0.05 was considered statistically significant. Physical stress induced changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), RPP & DoP were found to be significantly higher in normotensive individuals with family history of hypertension as compared to normotensive individuals without family history of hypertension.
Conclusion: The present study suggest that increased in blood pressure, heart rate, RPP and DoP in normotensive individual with F/H/O, which in turn increases the risk of CV dysfunction (Hypertension) in these subjects by increasing their myocardial energy expenditure.

Key words: Physical Stress Test, Blood Pressure, Heart rate**,** Rate Pressure Product, Family History of Hypertension.

INTRODUCTION

Hypertension is known to be a major predisposing factor for cardiovascular disease. Stress in any form –affect the cardiovascular system. Cardiovascular system is vital system which supplies oxygen and nutrients to all organs (Guyton et al., 2006). And heart itself required constant supply of oxygen for its regular function. Many parameters have been used to predict cardiac risk. An elevated heart rate at rest is confirmed as an independent risk factor for sudden death in middle-aged men (Xavier Jouven, 2001). The purpose of this study was to evaluate the clinical significant alteration to physical stress, which is considered an early marker of future hypertension. And to find out whether the use of energy demands was different in individual with or without family history of hypertension. Myocardial oxygen consumption (MVO2) is a good index of the coronary circulation and increased myocardial oxygen demand (Siti Nur Baait Biniti Mohd Sokran, 2015). Direct measurement of MVO2 is difficult procedure in clinical practice.MVO2 can be easily calculated by indirect methods like Stroke work, Fick's Principle, the tension time index and Rate Pressure Product (RPP) (Sarnoff, 1958). Rate pressure product (Katch Victor et al., 2010) also known as Cardiovascular Product is used in cardiology and exercise physiology to determine the cardiovascular risk of subjects. It will be a direct indication of the energy demand of the heart and thus a good measure of the energy consumption of the heart. Rate pressure product allows us to calculate the internal workload or hemodynamic response. RPP is a correlate of myocardial oxygen consumption, and hence of work load of the heart. When workload is very high, there is Inability to supply oxygen to the myocardium which related to several cardiovascular events, including transient myocardial ischemia, acute myocardial infarction, and sudden death. Myocardial oxygen consumption is correlated with the rate-pressure product (heart rate x systolic blood pressure). Hence It is considered as determinant of cardiovascular risk (Rajalakshmi et al., 2013). Thus RPP is used to measure the workload or oxygen demand of the heart, and reflects hemodynamic stress. RPP increases with the increased workload on the heart to provide the adequate blood supply to the myocardium during exercise. In healthy people, RPP changes in accordance with increased myocardial blood flow

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and oxygen consumption during exercise. Any total value greater than 10,000 indicates an increased risk for heart disease (McArdle, 2005). Double product (DoP) is used as an estimate of myocardial (heart muscle) work and is proportional to myocardial oxygen consumption. Strength training reduces the resting double product, indicating a decrease in myocardial oxygen consumption at rest.

MATERIALS AND METHODS

In this study, 60 subjects are without family history of hypertension (Control group) and 60 subjects with family history of hypertension (Test group). All subjects were normotensives (bra-chial blood pressure <140/90 mm Hg and not on drug treatment), nonobese (Boby Mass Index <25 kg/m2), non-smokers and the subjects from both groups were age and sex matched. Subjects were recruited and examined from the 1st and 2nd MBBS student population of Seth G S Medical College, Parel, and Mumbai. Subjects were screened for general physical health. A positive family history of hypertension was considered to be present when at least one of the parents was hypertensive. The parents with a positive or negative history of hypertension were identified by evidence of antihypertensive treatment in their medical history/ records. All subjects gave written consent to participate in the study. The study was approved by the Institutional Ethical Committee All subjects in the study satisfied the inclusion and exclusion criteria.

Procedure

After an overnight fast all subjects underwent noninvasive recording of baseline systolic and diastolic blood pressure (BP), heart rate, supine position. And from this calculate rate pressure product and double product. Subjects were asked to refrain from strenuous exercise or consumption of alcohol or caffeine containing beverages. They were subjected to physical stress in the form of Harvard step test. Harvard step test is a cardiovascular endurance test. The subject steps up and down on platform at a height of about 45 cm at a rate of 30/min for a total duration of 5 minutes or until exhaustion. Exhaustion is the point at which the subject immediately sits down on completion of test and blood pressure and heart rate response at 1, 2, 3, 4, 5, 7 and 10 minutes after exercise was recorded. Blood pressure for all subjects was recorded by the same examiner using automated blood pressure apparatus. The results were expressed as Mean ± SD and analyzed using Independent t- test (unpaired t-test) for comparison between the control group and test group and one way ANOVA test. The "P" value < 0.05 was considered statistically significant.

Rate Pressure Product Calculation: It is also known as Robinson Index (Siegelova et al., 2000). It is a product of systolic blood pressure and heart rate. RPP = Systolic Pressure in mm Hg x Heart Rate in beats/min x 10^{-2}. The value obtained is expressed as mm Hg. beats per min.10-2 (Mohan, 2005). Rate pressure Product [RPP] = (HR × SP)/100]. Double product (DoP=HR × MAP), MAP is mean arterial pressure Comparison of baseline parameters between two groups using Student t- test

RESULTS

As per the statistical analysis, this table show that mean at baseline among Normotensive cases without F/H/O HTN group, which was less as compared to among Normotensive cases with F/H/O HTN and but the difference was not statistically significant. If compared the control group with test group for SBP at the end of 1, 2, 3, 4, 5, 7 and 10 minutes then F/H/O HTN group showed significantly more rise as compared to without F/H/O HTN group ($p<0.001$). While DBP showed significance only at 3, 4, 5 and 10 minutes when compared control group with test group ($p<0.001$). If compared the control group with test group for HR at the end of 1, 2, 3, 4, 5, 7 and 10 minutes then F/H/O HTN group showed significantly more rise as compared to without F/H/O HTN group ($p<0.001$). If compared the control group with test group for PP and MAP at the end of 1, 2, 3, 4, 5, 7 minutes then F/H/O HTN group showed significantly more rise as compared to without F/H/O HTN group ($p<0.001$). While PP at 10 min.was non significant and MAP was highly significant in F/H/O HTN group.

Comparison of baseline parameters between two groups using Student t- test

Sr.no	Parameters	Control group Mean±SD	Test group Mean±SD	P value
1	Baseline SBP (mmHg)	112.47±7.28	113.98±7.92	0.2791
2	Baseline DBP(mmHg)	73.67±6.53	74.43±7.07	0.5419
3	Baseline PP(mmHg)	38.80 ± 5.40	39.55 ± 7.42	0.5280
4	Baseline MAP(mmHg)	63.36 ± 5.26	64.36 ± 6.82	0.3703
5	Baseline HR (beat/min)	078.50±05.96	078.97±06.63	0.6837
6	Baseline RPP	88.34 ± 9.27	90.17 ± 11.20	0.3316
7	Baseline DoP	4970.24 ± 530.03	5089.33 ± 739.04	0.3125

Comparison of exercised induces Mean SBP and DBP between two groups by one way ANOVA.

Difference (baseline – min)	Mean SBP (mm Hg)			Mean DBP (mm Hg)		
	Control group Mean±SD	Test group Mean±SD	P Value	Control group Mean±SD	Test group Mean±SD	P Value
1	23.83±6.92	31.69±8.57	0.001*	5.83±5.35	6.40±5.02	0.548
2	22.63±6.49	30.62±8.03	0.001*	4.40±5.64	6.00±5.66	0.123
3	17.36±6.03	25.35±8.25	0.001*	2.33±5.68	5.30±5.71	0.005*
4	12.13±6.26	20.79±8.44	0.001*	1.40±5.62	4.23±6.09	0.009*
5	08.60±6.16	18.09±7.78	0.001*	0.47±5.81	3.93±6.38	0.002*
7	02.55±5.38	10.95±7.35	0.001*	–1.37±5.36	3.30±6.81	0.087
10	–01.44±3.92	03.52±3.82	0.003*	–0.83±4.33	2.80±5.02	0.023*

Comparison of exercised induces Mean HR between two groups by one way ANOVA.

Difference (baseline – min)	Mean HR (beat/min) Control group Mean±SD	Test group Mean±SD	P Value
1	54.50±11.98	59.47±11.11	0.201*
2	47.13±11.55	53.60±11.23	0.0023*
3	40.13±11.29	47.17±11.00	0.0007*
4	32.53±11.01	39.53±10.79	0.0007*
5	26.33±10.92	31.27±09.64	0.0097*
7	18.77±9.85	24.10±8.73	0.0022*
10	12.23±8.28	19.57±7.77	0.0000*

Comparison of exercised induces Mean PP & MAP between two groups by one way ANOVA

Difference (baseline – min)	Mean PP (mm Hg) Control group Mean±SD	Test group Mean±SD	P Value	Mean MAP (mm Hg) Control group Mean±SD	Test group Mean±SD	P Value
1	18.00±7.48	25.28±8.87	0.001*	19.94±6.85	27.42±8.45	0.001*
2	18.23±6.79	24.62±8.11	0.001*	19.70±6.14	26.62±7.63	0.001*
3	15.03±6.65	20.05±8.02	0.001*	15.81±5.87	21.82±7.64	0.001*
4	10.73±6.92	16.55±8.56	0.001*	11.20±6.16	17.96±8.02	0.001*
5	08.13±7.55	14.15±8.79	0.001*	8.28±6.57	15.46±7.91	0.001*
7	3.92±7.32	7.65±8.55	0.0011*	3.46±6.25	8.75±7.52	0.001*
10	–0.60±5.87	0.72±5.22	0.196	–0.88±4.89	1.65±4.18	0.003*

Comparison of exercised induces Mean RPP & DoP between two groups by one way ANOVA.

Difference (baseline – min)	Mean RPP (mm Hg) Control group Mean±SD	Test group Mean±SD	P Value	Mean DoP (mm Hg) Control group Mean±SD	Test group Mean±SD	P Value
1	92.98±19.12	111.38±17.12	0.001*	6118.47±1415.32	7602.14±1288.74	0.001*
2	81.32±17.09	101.49±17.07	0.001*	5462.14±1201.75	6967.45±1219.68	0.001*
3	65.65±16.08	85.56±16.55	0.001*	4422.14±1125.85	5778.67±1144.84	0.001*
4	50.03±15.61	69.40±15.89	0.001*	3312.96±1081.30	4656.69±1109.90	0.001*
5	38.54±14.31	55.42±13.88	0.001*	2535.83±956.90	3710.80±986.41	0.001*
7	23.53±12.35	38.54±11.56	0.001*	1529.74±847.98	2441.11±819.90	0.001*
10	12.41±9.25	25.66±9.74	0.001*	698.65±583.86	1418.36±624.52	0.001*

If compared the control group with test group for RPP and DoP at the end of 1, 2, 3, 4, 5, 7 and 10 minutes then F/H/O HTN group showed significantly more rise as compared to without F/H/O HTN group ($p<0.001$).

DISCUSSION

Today's world is world of modernization which is full of stress. This leads to stress induced disorder, of which hypertension is most common. In our body, stress is responsible for increasing the sympathetic outflow which leads to an increased heart rate and increased blood pressure, which can be damaging. In normal individual usually these parameters return to normal level after the removal of the stress. The persons who show abnormal cardiovascular response to a stress and slower recovery rate after the removal of the stress that caused sympathetic stimulation which indicate that their autonomic control system is not efficient to bring down the blood pressure to baseline quickly. Naturally, they are at high risk for developing hypertension in their future life. Hypertension has familial disposition. People with family history of hypertension showed greater and prolonged responsiveness to sympathetic stimulation in comparison to the subjects from non- hypertensive families. *S Kurl, J. A. Laukkanen et al. in their study showed the importance of* systolic blood pressure (SBP) during exercise which has been used to predict a future diagnosis of hypertension (Kurl et al., 2001).

The systolic blood pressure during standardized progressive exercise testing may be a useful tool for prediction of future strokes and may help to identify subjects at high risk of stroke. Some study showed that person with family history of higher blood pressure or having high resting heart rate show blood pressure hyper-responsiveness to stress. Various researchers also observed greater SBP and catecholamine response to acute stress, showing a precedence of greater cardiovascular reactivity of stressors in men (Lakshmi Thimmaraju, 2014). Against this background, present study was conducted to evaluate effect of exercise on blood pressure, heart rate, rate pressure product and double product in normotensive individuals with parental history of HTN and to compare it with normotensive individuals without parental history of HTN. On exposure to sympathetic stimulation during physical stress (Harvard step test), the heart rate and blood pressure rises significantly. And Rate Pressure Product is a multiplication of systolic blood pressure and heart rate is expected to rise. The myocardial oxygen consumption (MVO2) also increases due to exercise which is reflected by increased RPP after exercise. Rate pressure product (RPP) is a major determinant of myocardial oxygen consumption hence is an important indicator of ventricular function. RPP varies with exercise such that the higher the peak RPP, the more will be myocardial oxygen consumption (MVO2). The ability to reach higher RPP is associated with adequate coronary perfusion.

Another study showed that, The percentage increase in RPP was significantly more in postmenopausal women with CAD (62%) as compared to premenopausal women with CAD (54%) indicating more compromised coronary perfusion in postmenopausal women (Sangeeta Nagpal et al., 2007). As reported earlier also, there was significant increase in SBP, HR and RPP with exercise, due to increase in sympathetic discharge. Some investigators have observed that angina pectoris occurs at a constant value of RPP and that the degree of ST segment depression is correlated with RPP. Thus the risk of cardiovascular problems increases with greater levels of RPP (Forjaz et al., 1998). Thus, a simple measurement of a resting rate pressure product and a change in rate pressure product in response to cardiac sympathetic stimulation can give a clue towards the status of myocardial blood flow in such patients. This can hence be used as a simple non-invasive predictor of cardiovascular risk in such patients. Thus, we tend to take RPP as an additional valuable marker predicting morbidity and mortality especially when exposed to times of increased myocardial demand like exercise or stress. Results of this study give an indication that the person who showed greater and specially prolonged responsiveness to blood pressure due to sympathetic stimulation through step test is prone to develop hypertension in his/her future life. In parallel to our findings it could also be suggested that subclinical autonomic neuropathy may be part of a genetic syndrome that includes augmented risk for developing cardiovascular disease (CVD), type 2 diabetes, symptomatic autonomic neuropathy and hypertension. Whether such development takes place could depend on exogenous factors such as nutrition, smoking and physical activity (Hauerslev Foss et al., 2001). In our study the increased blood pressure, heart rate, RPP and DoP observed in the individual of hypertensive parents, emphasize the importance of genetic influence on the prehypertensive phase of hypertension.

Conclusion

Findings of the present study suggest that increased RPP and DoP in normotensive individual with F/H/O, which in turn increases the risk of CV dysfunction (Hypertension) in these subjects by increasing their myocardial energy expenditure. Resting RPP as well as change in RPP gives coronary perfusion status. Future studies with more number of patients will help to further highlight the role of rate pressure product in predicting the extent of cardiac risk in such patients.

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