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SYMPATHETIC OVERACTIVITY IN OFFSPRINGS WITH HYPERTENSIVE PARENTS.

Physiology

Dr Nadeema Rafiq Senior Resident, Department of Physiology, G.M.C, Srinagar, J&K

Dr Suchet Trigotra Professor, Department of Physiology. Dr.Y.S.Parmar Government Medical College, H.P

Dr Tauseef Nabi* Senior Resident, Department of Endocrinology, SKIMS, Srinagar, J&K *Corresponding Author

ABSTRACT

Background: Parental history of hypertension increases the risk of developing future hypertension. Altered sympathovagal nervous system is reported in children of hypertensive parents.

Aims and Objective: To evaluate and compare cardiovascular autonomic functions in offspring of hypertensive and normotensive parents

Methods: 150 healthy young students of MMU aged 18–25 years, divided into Group A (FH+)(having family history of hypertension) Group B (offspring of normotensive parents). Various autonomic function tests done were Lying to Standing test, Valsalva manoeuvre, Hand grip test (HGT) and Cold pressor test (CPT).

Results: The mean basal heart rate of Group A was found significantly higher when compared with Group B. No parasympathetic alteration between two groups was seen. Values of HGT and CPT were significantly raised for Group A than for Group B, indicating higher sympathetic activity in offspring of hypertensive parents.

Conclusion: Offspring's of hypertensive parents have increased sympathetic reactivity, with no parasympathetic modulation in early life as compared to offspring of normotensive parents. The participants at high risk in our study are young offspring of hypertensive parents although being normotensive but have higher susceptibility for development of future hypertension. So weight reduction and moderate intensity aerobic exercise programmes should be incorporated in daily living, which may delay or prevent the onset of hypertension.

KEYWORDS

Autonomic function tests; Lying to Standing test; Valsalva manoeuvre; Hand grip test (HGT); Cold pressor test (CPT).

Introduction

Hypertension is a global problem that affects 1 billion people worldwide and is the cause for 7.1 million deaths each year from ischemic heart disease and stroke.[1,2,3].The prevalence of hypertension and its complication is projected to increase 60% by 2025, which accounts for about 1.58 billion adult's worldwide.[4] Uncontrolled blood pressure (BP) predisposes to coronary artery disease, left ventricular hypertrophy, end-stage renal disease, transient ischemic attack, cerebrovascular accidents, peripheral vascular disease and damage to retinal blood vessels and visual impairment.[5]

Hypertension runs in families and parental history of hypertension increases the risk of developing hypertension, especially if both parents are hypertensive.[6]In all, 25% of children with one hypertensive parent and 50% of children with two hypertensive parents will eventually become hypertensive.[7] In twin studies, heritability estimates of blood pressure are ~60% for males and 30-40% for females. The heritable component of blood pressure has been documented in various studies suggesting that 30%-50% of the variance of blood pressure readings are attributable to genetic heritability and about 50% to environmental factors.[8] Blood pressure is higher in children of hypertensive families than of unrelated individuals, greater between monozygotic than dizygotic twins.[9] High blood pressure before the age of 55 occurs 3.8 times more frequently among persons with a positive family history of hypertension.[10]

Autonomic abnormality in the form of increased sympathetic tone (increased norepinephrine levels), has been demonstrated in young normotensive offspring of hypertensive parents.[11] Hypertension in young subjects has been suggested to be neurogenic in origin. The changeover of neurogenically initiated hypertension to non-neurogenically maintained hypertension is slow.[12] Several disturbances have been reported in normotensive offspring of hypertensive parents and include: a) an exaggerated pressor responsiveness to exogenous norepinephrine (NE) in the presence of normal endogenous plasma NE concentrations b) an exaggerated sensitivity of the forearm vasculature to exogenous NE c) an altered baroreceptor function d) an increased responsiveness of BP to mental stress e) high plasma catecholamines concentration during stress f) a disturbed BP regulation after standing and g) an abnormal response of renal plasma flow to psychological stimuli Whether and to what extent, these aberrations contribute in the pathogenesis of essential hypertension are presently unclear.[13,14,15] Though hypertension is common in middle aged and elderly population, prehypertension is relatively more common in young adults, especially in those who have family history of hypertension and also high Body Mass Index (BMI).[16,17,18]

Blood pressure in children is by far the strongest predictor of adult BP levels. It is therefore, important to recognize children and adolescents who carry an increased risk of developing essential hypertension in adulthood. Offspring of hypertensive parents represent an excellent opportunity to study the early subclinical phases of the systemic hypertension. These children and adolescents can then be counseled to adopt preventative strategies towards risk factors such as obesity, high salt intake and lack of exercise.[19] Hence our study was conducted to evaluate and compare Cardiovascular Autonomic Functions in young adult students of Maharishi Markandeshwar University (MMU) with and without parental history of hypertension, to identify any early cardiovascular autonomic changes that may be predictive of future hypertension in offspring's with family history of hypertension.

MATERIAL AND METHODS

Study design and setting:

This was a cross-sectional study conducted in the department of Physiology, Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana (Ambala). Informed and written consent of all the participants was taken before conducting the study. The study was approved by institutional ethical committee.

Methodology:

Study participants:

The total of 150 randomly selected, young healthy students of MMU participated in our study, which were divided into two groups according to the parental history of hypertension. The parents with positive or negative history of hypertension (as per JNC 8) were identified by the evidence of antihypertensive treatment in their medical record. A positive parental history of hypertension was considered to be present when at least one of the parents was hypertensive. The study was conducted over period of one year (February 2013- January 2014).

Group A (FH+) (N= 73) included Offspring of hypertensive parents (one or both parents hypertensive) (FH+: Family History positive).

Group B (N= 77) Offspring of normotensive parents.

In our study we also subcategorized the participants into three groups:

(Group P_0) (N=77) offspring's with no parental history of hypertension,

(Group P_1) (N=66) offspring's with one parent having history of hypertension and

(Group P_2) (N=7) offspring's with both parents having history of hypertension

Eligibility criteria:
Inclusion criteria included apparently healthy participants between age group of 18-25 years, with systolic and diastolic blood pressure < 140/90 mm/Hg.

Exclusion criteria included i) Students on anti hypertensive drugs or any other medication. ii) Students under-going regular physical training iii) Students with history of acute or chronic illness like diabetes mellitus, renal disease or any neuro-psychiatric disorder which can affect autonomic function.

Procedure:
150 participants, who fulfilled inclusion criteria, were explained about the procedure of tests. Detailed history was taken and clinical examination was done. All the participants were tested under similar laboratory conditions in comfortable environment. Participants were instructed not to have heavy meals/tea/coffee at least 2 hours before test and were asked to rest just before the commencement of test, and then all basal parameters like heart rate, blood pressure and respiratory rate were measured. The Anthropometric data age, height, weight was noted and Body Mass Index (BMI) was calculated.

Measurement of BMI:
Body Mass Index (BMI) was calculated using Quetelet index.[20] **Normal weight** was defined as BMI 18.5 to ≤ 22.9, **Under weight** as BMI < 18.5, **Overweight** as BMI 23 to ≤ 24.9 and **Obesity** as BMI ≥ 25 kg/m2, as per revised body type classification for Indian Population recommended by Health ministry and Diabetes Foundation of India in 2008.[21]

Various Cardiovascular Autonomic function tests that were performed are as follows:

A. Parasympathetic tests:

1. Heart rate response to Standing (Lying to Standing test):
In this test heart rate response to standing was assessed. Each participant initially took supine rest on a couch for 5 min and base line ECG was recorded. Then subject attained standing posture within 3 seconds. A continuous ECG (lead II) was recorded during the procedure for measuring heart rate. 30:15 ratio was calculated as ratio of longest R-R interval at or around 30th beat after standing / shortest R-R interval at or around 15th beat after standing. Normal value of 30:15 ratio ≥ 1.04.[22]

2. Heart rate changes during the Valsalva manoeuvre (Valsalva Ratio):
The test was done in sitting posture. The subject blowed into a mouth piece attached to sphygmomanometer to raise the pressure to 40 mmHg for 15 seconds. At the end of 15 seconds the pressure was released. A continuous ECG (lead II) was recorded 1 minute before the manoeuvre, during the manoeuvre and 40 seconds following release of strain period. Valsalva Ratio was calculated as ratio of longest R-R interval after the strain / shortest R-R interval during the strain. Normal value of Valsalva Ratio > 1.21[22]

B. Sympathetic tests:

1. Blood pressure response to sustained Hand Grip Test (HGT):
After baseline blood pressure, the subject was asked to press handgrip dynamometer at 30% of maximum voluntary contraction (MVC) for 15 seconds. Blood pressure was recorded just before the release of hand grip after 1 minute and 5 min of grip release. Maximum rise in diastolic blood pressure above baseline was noted. A rise of more than 10 mmHg in diastolic blood pressure after test was considered normal.[23]

2. Blood pressure response to Cold Pressor Test (CPT):
After baseline blood pressure was recorded, the subject was instructed about the test. Subject immersed the right hand in cold water ($10\ ^0$C) up to the wrist without touching the bottom of cold water bath, for 1 minute. He was instructed to indicate to the investigator if he was not able to keep the hand immersed in water for 1 minute. After that hand was removed from water and covered by the towel. The blood pressure was recorded from left hand just at the end of 1 minute of immersion and again at 1 minute after hand was withdrawn from the cold water. A rise of 10mmHg in diastolic blood pressure after test was considered normal.[22]

Each test was performed after a resting period of 10 minutes, in supine or sitting position. Blood Pressure recording was done by using an Omron (SEM 1 Model), the automatic blood pressure monitor (Omron Healthcare Co. Ltd, Kyoto, Japan). The heart rate was measured from R-R interval of ECG using lead II of Electrocardiograph machine (CADIART 108T-DIGI, BPL LIMITED). Hand grip strength was measured from Handgrip Dynamometer.

STATISTICAL ANALYSES
The collected data was tabulated and analyzed with the help of Statistical Package for Social Sciences SPSS for WINDOWSTM (version 20). Students independent t test for quantitative differences was used for data analysis. Inter-group comparison was done by one way Anova with post hoc test. Mean ± standard deviations were calculated and t-test was applied for measuring statistical significance in difference of means. $P < 0.05$ was considered statistically significant and $P \leq 0.001$ was considered highly significant.

OBSERVATION AND RESULTS
In our study the total number of participants in Group A (Family History positive) (FH+) was 73 (48.70%) and Group B was 77 (51.30%).The number of males and females in Group A was 33 and 40 respectively. The number of males and females in Group B was 40 and 37 respectively. No significant difference was observed in mean age, weight and height among two groups, although BMI of Group A was found slightly higher than Group B (Table 1). The **mean basal heart rate** of Group A was found significantly higher when compared with Group B (***P* = 0.02**). There was no statistically significant difference in the values of parasympathetic tests in between the two groups (Table 2). But in case of **Sympathetic** tests (Table 3) the SBP (Systolic Blood Pressure) difference **HGT** for Group A (24.18 ± 11.44 mm/Hg) was found greater than for Group B (18.60 ± 8.90 mm/Hg) and the difference was statistically highly significant (***P* = 0.001**). Also the DBP (Diastolic Blood Pressure) difference **HGT** was found significantly raised for Group A (20.34 ± 8.94) than for Group B (15.31 ± 7.32). SBP difference **CPT** for Group A (18.15 ± 9.63 mm/Hg) was found greater than for Group B (14.14 ± 5.46 mm/Hg) (***P* = 0.002**). Mean of DBP after **CPT** for Group A was statistically highly significant than for Group B**.** Also the mean of DBP difference **CPT** was found highly raised for Group A (17.37 ± 6.36 mm/Hg) than for Group B (13.86 ± 4.98 mm/Hg).The **mean basal heart rate** of Group P_2 (86.7 ± 7.5 beats /min) was higher when compared with Group P_0 78.7 ± 9.5 beats/min and Group P_1 81.9 ± 10.3 beats /min, the difference was found to be statistically significant (***P* = 0.035**) as shown in Table 4. The mean DBP difference **HGT** was also raised in Group P_2 (21.9 ± 12.2 mm/Hg) than Group P_0 (15.3 ± 7.3 mm/Hg) (***P* = 0.001**) as shown in Table 6. The mean of DBP before and after **CPT** were found significantly higher for Group P_2 (74.0 ± 4.1mm/Hg and 88.9 ± 6.8 mm/Hg) than Group P_1 (67.9 ± 6.9 mm/Hg and 85.3 ± 9.6 mm/Hg) and Group P_0 (66.2 ± 7.7mm/Hg and 80.2 ± 10.2 mm/Hg) (***P* = 0.021**) and (***P* = 0.003**) respectively. While, inter group comparison of *P* values of DBP difference **HGT** is highly significant for Group P_0 vs Group P_1 (***P* < *0.001*)** followed by Group P_0 vs Group P_2 (***P* = 0.036**) while in between Group P_1 vs Group P_2 is not significant (*P* = *0*.641). In case of **CPT**, both SBP and DBP difference CPT is highly significant for Group P_0 vs Group P_1.

DISSCUSSION
Hypertension is an elevated arterial pressure which is usually asymptomatic but readily detectable and treatable condition and often leads to lethal complications if left untreated. It is an iceberg disease.[24]Hypertension is often associated with increase sympathetic outflow both in normal weight and obese individuals. Sympathetic outflow tends to be higher in hypertensive than normotensive individuals. Autonomic abnormality in the form of increased sympathetic tone has been demonstrated in young normotensive offspring of hypertensive parents.[12]

In our study there was no significant difference between the participants of Group A and Group B for demographic characteristics, including age, height, weight, body mass index (BMI). Majority of the basal parameters between two groups were similar except that the Group A had higher basal heart rate than the Group B.

Evaluation of parasympathetic tests primarily provide an index to cardiac vagal functions. Although parasympathetic tone decreases as hypertension progresses, our study did not exhibit any changes in both these tests between Group A and Group B.This result is in concordance with the study of Rathi et al. (2013) who studied autonomic functions in children of hypertensive parents and found no difference in parasympathetic response between children of hypertensive and normotensive parents.[1] This is also in agreement with Miller [25] and Visser et al.[26] although they used a different method for measuring the vagal response. However, despite our use of a different stressor, our study paralleled previous studies: we found no differences between the two groups in parasympathetic response. Perhaps the decrease in vagal tone seen in essential hypertensive subjects develops as a consequence of high blood pressure rather than as a precursor to the disease.[25] Contrary to our study Maver et al. [27] (2004) and Sogan et al. [28] (2012) reported decreased parasympathetic activity in normotensive persons with a positive family history of hypertension compared to the persons with a negative family history.

Sympathetic tests i.e HGT and CPT are of prognostic importance to determine sympathetic reactivity. Both tests cause peripheral vasoconstriction mediated by adrenergic receptors of sympathetic nervous system. [1] In our study, it was seen that there was no significant difference in the value of mean SBP and DBP before HGT in both the groups. While, mean SBP after HGT was found higher in Group A compared to Group B although not statistically significant (P=0.145). Mean DBP after HGT for Group A was higher than for Group B which was found to be statistically very highly significant ($P < 0.001$). Both mean SBP and DBP difference HGT for Group A was higher than Group B.

An increase in both the SBP and the DBP with the isometric handgrip exercise indicates activation of the sympathetic system, which may be due to increase in the plasma catecholamine level as was studied by Krzeminski K.[29] in cardiovascular and hormonal responses to static handgrip in young and older healthy men. The isometric hand grip exercise activates the mechanoreceptors immediately, due to the increased muscle tension. The recruitment of new motor units to maintain the muscle tension increases the excitatory state of the central nervous system and results in a possible increase in the sympathetic outflow and a decrease in parasympathetic outflow, which explain the increase in the blood pressure response.[30] It has been presumed that the pressure response to the isometric exercise is reflex in origin, which serves to increase the perfusion pressure to the active muscles, in which the blood flow is hindered by the sustained muscular contraction.[31] This may be the reason for the increase in the peripheral resistance and consequently, that in the blood pressure in our study. This can be explained on the basis, that the static (isometric) handgrip exercise causes an increase in the endothelin-1 in young normotensive offsprings of hypertensive parents and thus, an increase in the blood pressure.[32]

In case of CPT, mean DBP after CPT for Group A was higher than for Group B, which was found to be statistically highly significant (P = 0.001). Similarly, both mean SBP and DBP difference CPT for Group A was found significantly greater than for Group B. Sonia et al.,Kelsey et al., Ashwini et al. and Verma et al. in their studies found similar results and demonstrated that increased sympathetic reactivity is the main basic mechanism in the development of hypertension and increase in sympathetic activity may be a result of inheritance or a consequence of interaction between genetic and environmental factors.[9,33,34,35] Barnett et al. in his study stated that children of parents with hypertension are four times more likely to show increased vascular reactivity than the children of normotensive parents; which underlined the concept of inherited vascular reactivity.[36]

In our study the response to both the stress tests was highly raised in family history positive Group A. The results support the concept of inherited vascular reactivity as an indicator of sympathetic hyperactivity which is more or less a predictor of hypertension. The possible reason may be hypothalamus mediated reflex releasing NE at vascular smooth muscle cells, further accentuated by concomitant release of endothelin1 in young normotensive offspring's of hypertensive parents and thus, an increase in the blood pressure.[31] Pramanik et al. suggested that subjects exhibiting greater and prolonged response to stress induced tests are more prone to develop hypertension.[37] Folkow hypothesized that repeated episodes of stress over time cause a change in the wall-to-lumen ratio of arterioles in subjects with genetic predisposition to hypertension, ultimately eventuating in a fixed increase in peripheral resistance and future hypertension. Thus, both genetic predisposition and environmental interaction may play necessary roles in this process.[38] In support of this view point, participants of Group A in our study did show a greater responsiveness to stress tests as compared to Group B participants. Similarly, results revealed by Lopes et al., Kelsey et al., Ashwini et al. and Verma et al. indicated that an increased cardiovascular reactivity is found in offspring of hypertensive parents, which may be attributed to increased sympathetic activity.[12,33,34,35]

The mean BMI of Group P_2 (26.8 ± 6.8 Kg/m²) was higher as compared to Group P_1 (24.0 ± 5.4 Kg/m²) and Group P_0 (23.8 ± 4.3 Kg/m²) but the difference was not statistically significant (P = 0.309). The basal heart rate of Group P_2 was higher when compared with Group P_0 and Group P_1, the difference was found to be statistically significant ($P < 0.05$). The basal diastolic blood pressure of Group P_2 was higher compared to Group P_1 and Group P_0 (P = 0.340). G. K. Pal et al. in a study Sympathovagal imbalance in prehypertensive offspring of two parents versus one parent hypertensive (2011) revealed BMI and basal heart rate of offspring's with both parents hypertensive was higher than single parent hypertension ($P < 0.05$).[19]

On inter group comparison of 30:15 ratio and Valsalva ratio, no significant difference was found in between the groups, indicating that there is no parasympathetic modulation in early life in offspring's of hypertensive parents.

The mean SBP difference HGT was much higher in Group P_2 than Group P_1 and Group P_0 (P =0.001). Similarly, mean DBP difference HGT was also found much higher in Group P_2 followed by Group P_1 and Group P_0 (P = 0.001).Similar, results were demonstrated by G. K. Pal et al. in which DBP difference HGT was statistically highly significant for both parents hypertensive (P = 0.0001). But in our study mean of SBP and DBP difference CPT was much higher in offspring's with one parent hypertensive than with both and no parent hypertensive ($P < 0.05$). On inter group comparison, it was found that both SBP and DBP difference HGT was highly significant for Group P_0 vs Group P_2 and Group P_0 vs Group P_1 while in between Group P_1 vs Group P_2 was insignificant.

In case of CPT, both SBP and DBP difference CPT was highly significant for only Group P_0 vs Group P_1 while it was insignificant for Group P_0 vs Group P_2 and Group P_1 vs Group P_2.

Our study revealed that a greater degree of increase in sympathetic drive was found in participants of one or both parent's hypertensive. We infer that risk of hypertension does increase significantly with positive parental history of hypertension but the magnitude of effect due to one parent or both parents hypertensive could not be clearly differentiated likely because number of participants in our study having both parents hypertensive was less.

Conclusion: Offspring's of hypertensive parents show increased basal heart rate and increased sympathetic reactivity, with no parasympathetic modulation in early life as compared to offspring of normotensive parents. The participants of high risk group in our study i.e young offspring of hypertensive parents, although being normotensive but have higher susceptibility for development of future hypertension. Regular monitoring of autonomic activity may prove to be a useful tool in predicting the future hypertensive.The present study emphasizes the necessity to lower sympathetic tone in young offspring of hypertensive parents so that they do not progress into the future hypertension. Life style modification such as weight reduction and moderate intensity aerobic exercise programme which may delay or prevent the onset of hypertension should be done.

LIMITATION

This study has certain limitations. A larger sample size is required before definitive recommendations can be made. Also, a longer follow-up period is required to completely evaluate the participants of high risk group in our study i.e young offspring of hypertensive parents.

Table 1. Comparison of Anthropometric parameters between Group A and Group B

	Group A (FH +) N=73	Group B N=77	*P* value*
	Mean ± SD	Mean ± SD	

Age(Years)	19.41 ± 1.84	19.18 ± 1.60	0.417
Weight(Kg)	63.99 ± 15.47	63.79 ± 13.84	0.935
Height(cms)	162.32 ± 9.43	163.40 ± 8.72	0.467
BMI(Kg/m²)	24.25 ± 5.57	23.796 ± 4.26	0.567

**P*-value <0.05 is considered statistically significant
SD = Standard deviation, N = Number

Table 2. Comparison of Parasympathetic tests between Group A and Group B

	Group A (FH +) N=73	Group B N=77	*P* value*
	Mean ± SD	**Mean ± SD**	
LYING TO STANDING TEST			
30:15 ratio	1.28 ± 0.13	1.28 ± 0.17	0.972
VALSALVA MANOEUVRE			
Valsalva Ratio	1.71 ± 0.30	1.70 ± 0.25	0.778

Table 3. Comparison of Sympathetic tests between Group A and Group B

Blood pressure (mm/Hg)	Group A (FH +) N=73	Group B N=77	*P* value*
	Mean ± SD	**Mean ± SD**	
HAND GRIP TEST (HGT)			
SBP Before HGT	110.53 ± 10.76	111.47 ± 11.39	0.607
SBP After HGT	133.71 ± 15.48	130.05 ± 15.12	0.145
SBP Difference HGT	24.18 ± 11.44	18.60 ± 8.90	**0.001**
DBP Before HGT	68.58 ± 8.28	67.64 ± 7.63	0.471
DBP After HGT	88.95 ± 11.25	82.22 ± 10.97	**<0.001**
DBP Difference HGT	20.34 ± 8.94	15.31 ± 7.32	**<0.001**
COLD PRESSOR TEST(CPT)			
SBP Before CPT	109.58 ± 10.31	111.66 ± 11.00	0.233
SBP After CPT	127.70 ± 13.61	125.74 ± 12.32	0.357
SBP Difference CPT	18.15 ± 9.63	14.14 ± 5.46	**0.002**
DBP Before CPT	68.48 ± 6.94	66.25 ± 7.75	0.065
DBP After CPT	85.64 ± 9.42	80.21 ± 10.19	**0.001**
DBP Difference CPT	17.37 ± 6.36	13.86 ± 4.9	**<0.001**

**P*-value <0.05 is considered statistically significant

Table 4. Comparison of Anthropometric parameters between Group P_0, Group P_1 and GroupP_2

	Offspring of No Parents Hypertensive Group P_0 N=77	Offspring of One Parents Hypertensive Group P_1 N=66	Offspring of Both Parents Hypertensive Group P_2 N=7	*P* value*
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Age(Years)	19.2 ± 1.6	19.4 ± 1.8	19.1 ± 2.2	0.656
Weight(Kg)	63.8 ± 13.8	63.8 ± 15.4	65.7 ± 17.1	0.945
Height(cms)	163.4 ± 8.7	162.9 ± 9.6	156.5 ± 5.0	0.152
BMI(Kg/m²)	23.8 ± 4.3	24.0 ± 5.4	26.8 ± 6.8	0.309

**P*-value <0.05 is considered statistically significant

Table 5.Comparison of Parasympathetic tests between Group P_0, Group P_1 and Group P_2

	Offsprings of No Parents Hypertensive Group P_0 N=77	Offsprings of OneParents Hypertensive Group P_1 N=66	Offsprings of Both Parents Hypertensive Group P_2 N=7	*P* value*
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
LYING TO STANDING TEST				
30:15 ratio	1.284 ± 0.16	1.289 ± 0.13	1.229 ± 0.11	0.613
VALSALVA MANOEUVRE				
Valsalva Ratio	1.696 ± 0.248	1.722 ± 0.30	1.587 ± 0.24	0.448

**P*-value <0.05 is considered statistically significan

Table 6. Comparison of Sympathetic tests between Group P_0, Group P_1 and Group P_2

Blood pressure (mm/Hg)	Offspring of No Parents Hypertensive Group P_0 N=77	Offspring of One Parents Hypertensive Group P_1 N=66	Offspring of Both Parents Hypertensive Group P_2 N=7	*P* value*
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
HAND GRIP TEST (HGT)				
SBP Before HGT	111.5 ± 11.4	110.6 ± 11.1	110.1 ± 7.5	0.872
SBP After HGT	130.1 ± 15.1	133.5 ± 15.4	135.9 ± 17.7	0.322
SBP Difference HGT	18.6 ± 8.9	23.5 ± 11#	30.4 ± 14.2#	**0.001**
DBP Before HGT	67.6 ± 7.6	68.4 ± 8.5	70.6 ± 6.1	0.606
DBP After HGT	82.2 ± 11.0	88.6 ± 11.3##	92.4 ± 10.9#	**0.001**
DBP Difference HGT	15.3 ± 7.3	20.2 ± 8.6##	21.9 ± 12.2#	**0.001**
COLD PRESSOR TEST(CPT)				
SBP Before CPT	111.7 ± 11.0	109.5 ± 10.8	109.9 ± 3.0	0.491
SBP After CPT	125.7 ± 12.3	127.9 ± 14.2	125.7 ± 6.9	0.598
SBP Difference CPT	14.1 ± 5.5	18.4 ± 9.9##	15.9 ± 7.2	**0.006**
DBP Before CPT	66.2 ± 7.7	67.9 ± 6.9	74.0 ± 4.1#	**0.021**
DBP After CPT	80.2 ± 10.2	85.3 ± 9.6#	88.9 ± 6.8#	**0.003**
DBP Difference CPT	13.9 ± 5.0	17.5 ± 6.5##	16.4 ± 4.7	**0.001**

**P*-value <0.05 is considered statistically significant.

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