e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2022; 14(5); 176-184

Original Research Article

A Comparative Study on the Effect of Isometric Hand Grip Exercise in Normotensive Offspring of Normotensive Vs Hypertensive Parents Assessed in Terms of Rate Pressure Product and Pulse Pressure

Nidhi Gupta[1], Kapil Gupta[2], Sanjay Kumar Singhal[3], Abhishek Saini[4]

[1]Associate Professor, Department of Physiology, S.M.S. Medical College, Jaipur, Rajasthan, India
[2]Professor, Department of Physiology, S.M.S. Medical College, Jaipur, Rajasthan, India
[3]Professor, Department of Physiology, S.M.S. Medical College, Jaipur, Rajasthan, India
[4]Assistant Professor, Department of Physiology, S.M.S. Medical College, Jaipur, Rajasthan, India

Received: 20-03-2022 / Revised: 23-04-2022 / Accepted: 09-05-2022
Corresponding author: Dr. Abhishek Saini
Conflict of interest: Nil

Abstract

Introduction: Rate pressure product (RPP) is a valuable marker of cardiac function and is expressed as a product of Heart Rate (HR) and Systolic Blood Pressure (SBP) (HR*SBP/1000). Pulse Pressure (PP) is the difference between systolic and diastolic blood pressure and depends on the interplay between cardiac output and peripheral resistance.

Aim: RPP and PP responses to isometric hand grip exercise (IHG) were measured and compared among offspring of normotensive and hypertensive parents to reveal the differential change in patterns of these parameters so as to objectively unearth the predisposition towards development of hypertension at a later age.

Material and methods: The present study was a case control study wherein two groups namely, "Cases" and "Controls" were formed comprising 45 subjects in each, on the basis of presence or absence of hypertension in parents, respectively. While forming the groups, age, gender and Body mass index (BMI) matching was ascertained resulting in recruitment of 27 males and 18 females in each group. HR, SBP and diastolic blood pressure (DBP) were recorded at baseline, 4 minutes after starting IHG exercise ("during IHG") and 5 minutes after the end of IHG exercise (at "5-minute post IHG"). RPP and PP were calculated secondarily from the so obtained primary parameters. Statistical analysis was performed using Paired and Unpaired t-test while comparing among same group and between the groups respectively.

Results: The groups so formed, were comparable with respect to BMI. RPP and HR were found to be significantly higher in male cases in comparison to male controls in basal stage with a p value of ≤ 0.001. Significant increase in RPP, HR, SBP and DBP occurs in both cases and controls (in both males and females) during IHG exercise and remained significantly elevated post 5 minutes of IHG exercise only in cases ($p \leq 0.001$). No significant difference was observed in the basal PP between cases and controls (across both genders). During IHG no significant difference in PP was observed in control subjects (both male and female) as well as in male

subjects enrolled under case group. However, statistically significant change in PP was observed in female subjects constituting case group during IHG exercise ($p \leq 0.01$). Both male and female subjects enrolled under the case group demonstrated statistically significant change in PP after IHG exercise ($p \leq 0.01$).

Conclusion: RPP and PP are promising markers for assessment of autonomic reactivity and can serve as objective tools for deciphering the propensity of development of hypertension in normotensive individuals later in life.

Keywords: Heart Rate, Systolic Blood Pressure, Rate Pressure Product, Pulse Pressure, Isometric hand Grip Exercise.

Introduction

Essential hypertension is a heterogeneous group of disorder wherein the disease process is progressive and spans several decades of life. It has been documented that parental history of hypertension has been associated with higher systolic and diastolic blood pressure in their offspring [1,2] and that genetic factors do play a role in it [3]. Likewise, it has also been reported that cardiovascular/haemodynamic response to repeated mental stress in normotensive offspring of hypertensive parents show enhanced reactivity, blunted adaptations and delayed recovery when evaluated with appropriate cardiac and/or autonomic function tests [4]. Isometric hand grip test is one such test that is standardized, sensitive, specific, reproducible, simple and non invasive & being used for evaluation of sympathetic functions [5-7]. The test has been used to demonstrate that healthy young offspring of hypertensive parents had higher resting and post exercise systolic and diastolic blood pressures than offspring of normotensive parents [8].

RPP is defined as the product of heart rate (HR) and systolic blood pressure [9] and it is calculated as RPP = SBP*HR/1000, expressed as mmHg beats per min × 1000 [10,11]. RPP is a reflection of internal myocardial work performed by the beating heart and is a marker of oxygen requirement in the heart [12]. It is an index of cardiac stress and ventricular function at rest and during isometric exercise. As the heart rate and blood pressure are buffered with each other by baroreceptor reflex, rate pressure product can be a marker of autonomic buffering operating in accordance to the needs of the body [12].

PP is the difference between systolic and diastolic blood pressure and any variation in it following isometric exercise mirrors the differential predominant response on systolic or diastolic blood pressure [12].

The aim of the present study was to objectively state and determine the propensity of development of hypertension later in life in normotensive offspring of hypertensive parents using response to isometric hand grip exercise assessed in terms of RPP and PP marking the early abnormalities in autonomic functions in these subjects.

Material and methods

The present study was cross sectional, done in SMS Medical College, Jaipur, Rajasthan, India on 45 offspring of hypertensive parents (considered as cases with 27 males

and 18 females) and 45 offspring of normotensive parents (considered as controls with 27 males and 18 females) after taking approval from the institutional research review board and ethical committee (No. 346/MC/EC/2011). A total sample size of 80 subjects (40 subjects in each group) was calculated at 95% confidence (α = 0.05), 80% power (β) & effect size (d) of 0.8 to verify the difference of 3.3 in mean RPP and 2.3 in standard deviation in study groups. The sample size has been enhanced to 45 subjects in each group for expected 10% dropouts. This sample size was also adequate to cover all other study variables. All the subjects were 17-25 years of age and both groups were comparable with respect to gender and BMI. The subjects were selected from a batch of 250 M.B.B.S. students by simple random sampling of eligible subjects after selecting and sorting them for the presence or absence of hypertension in the parents. Written informed consent was obtained from the participants after making them understand the importance of the project, their role in the project and the procedural part.

Parental history of essential hypertension was ascertained from the medical prescriptions after prior affirmation by the subjects for the presence of hypertension in parents. Subjects with cardiovascular disease, thyroid disease, diabetes mellitus or any other chronic or acute illness and on medication especially affecting autonomic functions, smokers and alcoholics were excluded from the study.

The subjects were instructed to abstain from food for 3 hours and exercise for 12 hours prior to the test procedure. Body weight was measured with bare foot and with light clothing on a weighing scale with a precision of 0.1 kg. Height was measured by stadiometer (to the nearest of 0.5 cm) while the subjects were instructed to stand upright and look in front with heels touching to one another. Heart rate was recorded manually after counting the radial pulse and blood pressure was recorded by mercury sphygmomanometer in supine posture in left arm (non-dominant, non-exercising arm). MVC (Maximum voluntary capacity) was obtained by calibrated spring type hand grip dynamometer with dominant hand with subjects seated in sitting posture. The subjects were asked to squeeze the bar of dynamometer with maximal effort and to maintain it for 2-3 seconds [13]. Three trials with a gap of 2 minutes were given to each subject and the best response was taken as MVC.

After resting in supine posture for 15 minutes, baseline HR and BP was taken. Subjects were then asked to do IHG exercise with 30% MVC effort with dominant arm for 5 minutes [14]. BP and HR were recorded 4 minutes after initiation of IHG ("during IHG") and 5 minutes after completion of IHG. All recordings were performed by a single research investigator using the same sphygmomanometer, cuff and stethoscope hence avoiding inter-observer bias.

Test variables were: BMI (Body mass index) = Weight (kg)/Height (m^2), RPP = HR*SBP/1000 and PP=SBP-DBP. Data were reported as mean ± standard deviation. Statistical analysis was done using Student 't' test (paired and unpaired) using primer software. Probability (p) value of <0.05 was considered statistically significant keeping the confidence interval at 95%.

Observations and Results

The results of study are summarized in Table1-6. Unpaited t-test was used to compare the baseline characteristics between suspects and controls. Paired t test was used to compare the study parameters between baseline and across the test procedure within the same group.

Table 1: Baseline characteristics of male subjects in the 2 groups

Variables	Cases (n=27)	Controls (n=27)	P value
BMI (kg/m^2)	21.39 ± 2.19	20.53 ± 3.22	NS
HR (bpm)	80.26 ± 9.68	73.29 ± 9.99	P = 0.001
SBP (mm of Hg)	115.7 ± 7.76	114.04 ± 8.47	NS
DBP (mm of Hg)	74.18 ± 8.99	74.51 ± 11.7	NS
RPP	9.29 ± 1.29	8.36 ± 1.4	P = 0.014
PP (mm of Hg)	41.63 ± 9.18	39.26 ± 11.6	NS

NS - Non Significante. Data represented in mean ± SD

Table 2: Baseline characteristics of female subjects in the 2 groups

Variables	Cases (n=18)	Controls (n=18)	P value
BMI (kg/m2)	20.76 ± 2.6	19.43 ± 2.37	NS (p=0.38)
HR (bpm)	85.17 ± 15.17	78.05 ± 7.69	NS (p=0.078)
SBP (mm of Hg)	111.11 ± 6.5	114.0 ± 8.7	NS (p=0.47)
DBP (mm of Hg)	77.11 ± 9.02	74.55 ± 9.06	NS (p=0.093)
RPP	9.49 ± 1.88	8.9 ± 1.1	NS (p=0.49)
PP (mm of Hg)	34 ± 6.4	39.44 ± 11.2	NS (p=0.061)

NS - Non Significante. Data represented in mean ± SD

Table 3: Effect of IHG test on HR, SBP, DBP, RPP and PP in control males

Parameters	At rest	During IHG	At 5 minutes post IHG
HR (bpm)	73.29 ± 9.99	77.4 ± 10.58* (p≤0.01)	72.62 ± 8.86
SBP (mm of Hg)	114.07 ± 8.47	124.81 ± 10.78* (p≤0.01)	115.11 ± 7.87
DBP (mm of Hg)	74.51 ± 11.17	85.03 ± 12.76* (p≤0.01)	74.44 ± 12.2
RPP	8.36 ± 1.40	9.7 ± 1.7* (p≤0.01)	8.38 ± 1.34
PP (mm of Hg)	39.26 ± 11.6	39.78 ± 9.78	40.67 ± 13.17

*Depicts comparison with parameters at rest (paired t test) p≤0.05. Data represented in mean ± SD

Table 4: Effect of IHG test on HR, SBP, DBP, RPP and PP in 'case' males

Parameters	At rest	During IHG	At 5 minutes post IHG
HR (bpm)	80.26 ± 9.68	86.63 ± 10.95* (p≤0.001)	84.81 ± 10.39* (p≤0.001)
SBP (mm of Hg)	115.7 ± 7.76	133.07 ± 12.54* (p≤0.001)	128.81 ± 9.87* (p≤0.001)
DBP (mm of Hg)	74.18 ± 8.99	89.00 ± 12.44* (p≤0.001)	82.4 ± 9.86* (p≤0.001)
RPP	9.29 ± 1.29	11.62 ± 2.12* (p≤0.001)	10.95 ± 1.72* (p≤0.001)
PP (mm of Hg)	41.63 ± 9.18	44.3 ± 13.37* (p≤0.05)	46.15 ± 11.57* (p≤0.05)

*Depicts comparison with parameters at rest (paired t test) p≤0.05. Data represented in mean ± SD

Table 5: Effect of IHG test on HR, SBP, DBP, RPP and PP in control females

Parameters	At rest	During IHG	At 5 minutes post IHG
HR (bpm)	78.05 ± 7.69	83.27 ± 8.45* (p≤0.001)	78.61 ± 8.43
SBP (mm of Hg)	114.0 ± 8.7	120 ± 8.27* (p≤0.001)	114.88 ± 8.09
DBP (mm of Hg)	74.55 ± 9.06	81.88 ± 8.49* (p≤0.001)	75.55 ± 7.84
RPP	8.9 ± 1.1	10.01 ± 1.24* (p≤0.001)	9.1 ± 1.15
PP (mm of Hg)	39.44 ± 11.12	38.22 ± 6.2	38.33 ± 7.07

*Depicts comparison with parameters at rest (paired t test) p≤0.05. Data represented in mean ± SD

Table 6: Effect of IHG test on HR, SBP, DBP, RPP and PP in suspect females

Parameters	At rest	During IHG	At 5 minutes post IHG
HR (bpm)	85.17 ± 15.17	91.17 ± 13.54* (p≤0.001)	89.72 ± 13.43* (p≤0.001)
SBP (mm of Hg)	111.11 ± 6.55	125.11 ± 9.4* (p≤0.001)	119.33 ± 11.76* (p≤0.001)
DBP (mm of Hg)	77.11 ± 9.02	86.88 ± 8.15* (p≤0.001)	81.22 ± 7.64* (p≤0.05)
RPP	9.49 ± 1.88	11.45 ± 1.88* (p≤0.001)	10.73 ± 2.05* (p≤0.001)
PP (mm of Hg)	34.00 ± 6.4	38.22 ± 6.75* (p≤0.05)	38.11 ± 8.8

*Depicts comparison with parameters at rest (paired t test) p≤0.05. Data represented in mean ± SD

Discussion

Isometric hand grip test is a standard test for assessment of the functions of sympathetic nervous system [6] wherein the pressure response to isometric exercise is characterized by an increase in heart rate and blood pressure [15,16]. Both, central and peripheral nervous inputs govern the cardiovascular adjustments to isometric exercise [17]. Afferent impulses from the exercising muscles arise via activation of

Type III afferents (mechanoreceptors) and type IV afferents (chemoreceptors) of muscle [18]. These impulses subsequently ascend in the spinothalamic tract to the medullary cardiovascular centres and lead to a net sympathetic stimulation (vagal withdrawal and/or sympathetic stimulation) resulting in increase in heart rate and blood pressure [19-21]. Central nervous system inputs following isometric contraction arise from higher centres (insular cortex) resulting in an increase in heart rate due to vagal withdrawal primarily [22]. During static exercise increased intramuscular pressure around the blood vessels in exercising limbs result in a higher increase in peripheral resistance & diastolic blood pressure in comparison to dynamic exercise [23]. Such an observation of a relatively larger increase in systolic blood pressure and pulse pressure occurring during isometric exercise is explained on the basis of hemodynamics where an excess increase in cardiac output occurs for restoring adequate circulation in isometric exercising muscles which were constricted by external intramuscular pressure.[23]

Rate pressure product has been stated as a predictor of myocardial oxygen consumption and ventricular function, both at rest and during isometric exercise [24]. At resting state, heart rate and blood pressure regulate each other by feedback inhibition through baroreceptors, cancelling out absolute increments in each and therefore RPP which is a composite index involving product of blood pressure and heart rate serves as a better indicator of net sympathovagal balance of cardiovascular system since reciprocal variations in the blood pressure and heart rate are being taken care of. Also, even during exercise, RPP increase is adjusted as per the increase in myocardial oxygen demand [25], hence implying RPP as a better indicator of autonomic buffering both in rest and disease.

Offspring of hypertensive parents have been said to have a net increase sympathetic activity resulting in augmented cardiovascular responses following isometric exercise [26] which include greater increase in heart rate and blood pressure among others.

In our study, the male “cases” had significantly higher RPP and heart rate in comparison to male “controls” with no significant difference in blood pressure at the basal stage. However, a similar study done by Garg et al. demonstrated a significant increase in blood pressure in cases in comparison to controls in basal stage [8]. Such observed phenomenon of relative dominance of sympathetic activity in cases/suspects can be due to either vagal withdrawal (manifested primarily as increased HR) or increased sympathetic activity per se (manifested primarily as increased BP).[7] Because blood pressure and heart rate are related reciprocally, the present study proposes RPP as a better assessment tool for evaluation of sympathetic over-activity in comparison to HR or BP alone. A lower value of RPP is a marker of parasympathetic dominance and is believed to be cardio-protective [27]. In the present study, the female subjects demonstrated no significant difference in the cardiovascular parameters in the two groups at basal stage.

Significant increase in SBP, DBP and HR with an equally significant increase in RPP after Isometric Hand Grip exercise in both cases and controls (in both gender) is due to exercise induced increased sympathetic activity. Increase in RPP is indicative of the situation wherein the autonomic buffering action got well set in, facilitating coronary perfusion and O_2 consumption by the myocardium [24,25]. Pulse pressure

increased significantly in subjects of case group (in both gender) but not in subjects of control group possibly due to disproportionate increase in cardiac output in comparison to peripheral resistance. Julius et al. in 1983 and Sherwoood et al. in 1986 stated that there is an initial stage of myocardial activation (manifested as high cardiac output) progressing to a later stage of increased vascular reactivity in offspring of hypertensive parents [28,29].

During recovery from IHG exercise, the cardiovascular parameters returned to basal levels in male and female controls, but they remain significantly elevated as compared to resting levels in male subjects of suspect group. Normally there should be a post exercise fall in blood pressure due to vasodilatation resulting because of accumulation of metabolites following reduced blood supply in exercising muscles [30] accompanied with enhanced vagal activity and withdrawal of sympathetic activity resulting in decrease in cardiac output and heart rate [30]. However, in the present study, the subjects in the case group demonstrated impaired recovery pattern pointing towards increased sympathetic activity in them. In female subjects of the case group, all cardiovascular parameters remained significantly elevated during recovery except pulse pressure. The so observed normal recovery of pulse pressure to baseline can be due to gender difference in cardiovascular response to isometric hand grip exercise [30,31]. It has been previously demonstrated that blood pressure response to isometric exercise in females is mediated by increment in cardiac output whereas in men it is mediated by an increase in both cardiac output and peripheral resistance [30].

Conclusions

Rate pressure product and pulse pressure changes can be used in addition to blood pressure changes in early detection of at-risk offspring of hypertensive parents for risk of developing future hypertension.

Limitations

Small sample size especially of female subjects and lack of categorization of female subjects according to their menstrual history were limitations of the study.

References

1. Mitsumata K, Saitoh S, Ohnishi H.et al Effects of parental hypertension on longitudinal trends in blood pressure and plasma metabolic profile: mixed effects model analysis. Hypertension 2012; 60:1124-1130**.**
2. Whinchup PH, Cook DG. et al. Do maternal and intrauterine factors influence blood pressure in childhood. Arch Dis Child.1992;67:1423-1429**.**
3. Knuiman MW, Divitini ML. Familial correlations, cohabitation effects and heritability for cardiovascular risk factors. Ann Epidemiol.1996;6:188-194**.**
4. Steptoe A, Marnot M. Impaired cardiovascular recovery following stress predicts 3-year increase in blood pressure. J Hypertens 2005, 23; 529-536**.**
5. Lind AR. Cardiovascular responses to static exercise (isometrics, anyone?). Circulation 1970; 41:173-6.
6. Khurana RK, Setty A. The value of the isometric hand-griptest studies in various autonomic disorders. Clin Auton Res1996; 6:211-8.
7. Fisher ML, Nutter DO, Jacobs W, Schlant RC. Haemodynamic responses to isometric exercise (handgrip) in patients with heart disease. Br Heart J 1973; 35:422-32.
8. Garg R, Malhotra V, Dhar U, Tripathi Y. The isometric handgrip exercise as a test for unmasking hypertension in the offspring of hypertensive parents. J Clin Diagn Res 2013; 7:996-9**.**

9. http://www.ncsf. Org/2.8.2012: 8:45 AM. Understanding exercise intensity and rate pressure product (RPP) by NCSF on feb 17.2011**.**
10. Cockroft JR, Wilkinson IB, Evans M et al. Pulse pressure predicts cardiovascular risk in patients with type 2 diabetes mellitus. Am J Hypertens.2005 Nov ;18(11):1463-1467.
11. Mohan M, Kaviraja, Bhavanani A.et al. Effect of slow and fast pranayamas on reaction time and cardiorespiratory parameters. Indian J Physiol Pharmacol 2005; 49:313-318**.**
12. Sembulingam P, Sembulingam K, et al. Rate pressure product as a determinant of physical fitness in normal young adults. IOSR-JDMS.2015: Vol 14(4) :8-12**.**
13. Clausen JP, Klausen K, Rasmussen B, Trap-Jensen J. Central and peripheral circulatory changes after training of the arms or legs. Am J Physiol 1973; 225:675-82**.**
14. Hultman E, Sjöholm H. Blood pressure and heart rate response to voluntary and nonvoluntary static exercise in man. Acta Physiol Scand 1982; 115:499-501.
15. Donald KW, Lind AR, McNicol GW, Humphreys PW, Taylor SH, Staunton HP. Cardiovascular responses to sustained(static) contractions. Circ Res 1967; 20:15-30.
16. Lind AR, McNicol GW. Muscular factors which determine the cardiovascular responses to sustained and rhythmic exercise. Can Med Assoc J 1967; 96:706-15.
17. Mitchell JH, Payne FC, Saltin B, Schibye B. The role of muscle mass in the cardiovascular response to static contractions. J Physiol 1980; 309:45-54.
18. Asmussen E, Christensen EH, Nielsen M. Circulatory and cortical motor innervation. Scand Arch Physiol 1940; 83:181-7.
19. Mark AL, Victor RG, Nerhed C, Wallin BG. Microneurographicstudies of the mechanisms of sympathetic nerve responses tostatic exercise in humans. Circ Res 1985; 57:461-9.
20. Saito M, Mano T, Abe H, Iwase S. Responses in muscle sympathetic nerve activity to sustained handgrips of different tensions in humans. Eur J Appl Physiol Occup Physiol1986; 55:493-8.
21. Seals DR, Chase PB, Taylor JA. Autonomic mediation of the pressor responses to isometric exercise in humans. J Appl Physiol (1985) 1988; 64:2190-6**.**
22. Shepherd JT, Blomqvist CG, Lind AR, Mitchell JH, Saltin B. Static (isometric) exercise. Retrospection and introspection. Circ Res 1981;48: I179-88.
23. Hietanen E. Cardiovascular responses to static exercise. ScandJ Work Environ Health 1984; 10:397-402.
24. Nagpal S, Walia L, Lata H, Sood N, Ahuja GK. Effect ofexercise on rate pressure product in premenopausal andpostmenopausal women with coronary artery disease. Indian J Physiol Pharmacol 2007; 51:279-83.
25. Gobel FL, Norstrom LA, Nelson RR, Jorgensen CR, Wang Y. The rate-pressure product as an index of myocardial oxygen consumption during exercise in patients with angina pectoris. Circulation 1978; 57:549-56.
26. Lopes HF, Consolim-Colombo FM, Barreto-Filho JÁ, et al. Increased sympathetic activity in normotensive offspring of malignant hypertensive parents compared to offspring of normotensive parents. Braz J Med Biol Res.2008; 41:849-53**.**
27. Michael Afigneroa, Ronald E De Meersman, I and James Manning. The autonomic and rate pressure product

responses of Tai Chi Practitioners. N Am J Med Sci 2012 June; 4(6):270-275.
28. Julius S et al. The association of borderline hypertension with target organ changes and higher coronary risk. Tecumseh blood pressure study. Journal of American medical association. 1990; 264: 354-358.
29. Sherwood A, Allen MT, Obreist PA. Evaluation of beta-adrenergic influences on cardiovascular and metabolic influences on cardiovascular and metaboloic adjustments to physical and psychological stress. Psychophysiology 1986; 23:89-104.
30. Samora M, Anthony VI, ViannaCL. Sex difference in blood pressure regulation during ischaemic isometric exercise: the role of beta-adrenergic receptors. J Appl Physiol 2019; 127(2).408-414.
31. Akintomide AO, Asafa AM, Omole JG. Sex difference in cardiovascular response to handgrip exercise among apparently healthy young adult Nigerians. J Cardiol Curr Res 2016; 7(2): 00244.