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Diastolic Blood Pressure Response During Non - Isometric Exercise and Its Association with Family History of Hypertension

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Abstract: ***The purpose of this study was to find an association (if any) between isolated diastolic blood pressure response to non - isometric exercise and family history of hypertension. Diastolic blood pressure response (DBPR) of 32 apparently healthy young adults (aged 18 - 30 years) were noted during 10 minutes of cycling on a bicycle ergometer and during their recovery after exercise and their family history of hypertension were recorded by a separate observer.4 sets of data were rejected due to faulty technique and rest 28 sets of data were checked for association by a 2 by 2 contingency table and by performing Chi - Square test.17 subjects showed normal DBPR, 11 of them did not have any family history of hypertension, which should be a normal occurrence. And out of 11 subjects with abnormal/exaggerated DBPR, 6 had positive family history of hypertension, which was inconclusive. The test result gave us a more than 25% chance of randomness of association between abnormal/exaggerated DBPR and family history of hypertension, which refuted the association, meaning abnormal/exaggerated DBPR to non - isometric exercise and family history of hypertension can both be predictors of future hypertension but there is no association between them.***

Keywords: Diastolic blood pressure, Exaggerated blood pressure response, Family history of hypertension, Bicycle ergometry, Non - isometric exercise

1. Introduction

Hypertension is a leading cause of cardiovascular and cerebrovascular incidents in the modern era. It is of concern that it has affected not only adults and elderly but also children and adolescents due to their lifestyle (high calorie diet and lack of exercise).

It has been found from numerous researches that genetic factors play an immense role in development of hypertension. People who had family history of hypertension had a multiple fold higher risk of developing hypertension. [1]

It has been suggested that development of hypertension is preceded by a pre - hypertensive state which may be manifested by abnormal or exaggerated cardiovascular response to various isometric or dynamic exercises, mental and behavioural challenges. Several studies have indicated that subjects with normal resting blood pressure, who show exaggerated blood pressure response (EBPR) during exercise, are at greater risk of hypertension. [2, 3]

The blood flow to resting skeletal muscle is about 2–4 mL/100 g/min. When a muscle contracts, it compresses the vessels within it if it develops more than 10% of its maximal tension. However, when it develops more than 70% of its maximal tension, blood flow is completely stopped. In between contractions, blood flow is so greatly increased that flow per unit of time in a rhythmically contracting muscle is increased as much as 30 - fold. Local mechanisms maintaining a high blood flow in exercising muscle include a fall in tissue PO2, a rise in tissue PCO2, and accumulation of K+, H+ and other vasodilator metabolites. The temperature rises in exercising muscle which further dilates the vessels. Dilation of the arterioles and precapillary sphincters causes upto100 - fold increase in the number of open capillaries.

Within a few seconds of the onset of an *isometric* muscle contraction, Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) rise sharply. Stroke volume changes relatively less. The response to exercise involving *isotonic* muscle contraction is a prompt rise in heart rate and a marked increase in stroke volume occurs. In addition, there is a net fall in total peripheral resistance due to vasodilation in exercising muscles. Consequently, systolic blood pressure rises only moderately, whereas diastolic pressure usually remains unchanged or falls.

There have been various studies linking exaggerated Systolic blood pressure response to exercises with development of hypertension. The purpose of this study however, was to find an association, if any, between abnormal Diastolic blood pressure response to non - isometric exercise in an otherwise normotensive young adult and his family history of hypertension.

2. Literature Survey

Previous studies have shown that exaggerated blood pressure response to exercise is a valid risk factor for future hypertension, yet the use of an exercise test as a means of early prediction of hypertension still requires methodological approach and confirmation.

Assaf Berger et al. [4] found in a large cohort of normotensive middle - aged adults, blood pressure response to exercise, to be associated with future development of Hypertension. The main finding of the study was that among normotensive subjects, assessment of SBP and DBP response during exercise could be used to improve risk stratification with respect to future development of chronic hypertension.

Normally, during exercise, the Diastolic Blood Pressure falls owing to a decrease in the systemic vascular resistance, according to J. Fischer et al. [5]

However, Nobuyuki Miyai et al. [6] had studied 239 men with high - normal BP who underwent a symptom - limited bicycle ergometer exercise testing at baseline and found exaggerated BP response to exercise was an important risk factor for new - onset hypertension when followed up for 5.1 years. They had found that an exaggerated BP response to HR increase during ergometric exercise was associated with a 3 - to 4 - fold greater risk for developing hypertension. Therefore, the approach lent further support to the concept that exercise BP measurement is a valuable means for the identification of an increased risk of future hypertension in apparently healthy normotensive adults.

Also, J. Benbassat [7], had studied exaggerated BP response to exercise as a predictor of future hypertension. Published studies of the blood pressure response to exercise were reviewed to assess the probability of future hypertension in a subject with a "hypertensive" response to exercise. The reviewed data indicated that the sensitivity of a hypertensive response to exercise for future hypertension varied between 16% and 60%, and the specificity between 53% and 95%. The prevalence of hypertension on follow - up among normotensive subjects with a hypertensive response to exercise testing was 2.06 to 3.39 times higher than that among subjects with a normotensive response. Therefore, blood pressure response to exercise does have a predictive value for future hypertension.

3. Methodology

A cross - sectional, analytical study was conducted on 32 undergraduate medical students, aged 18 to 30 years, of IPGME&R, Kolkata who volunteered during their practical classes during the span of November, 2019 to March 2020. The study could not be carried on further due to the onset of COVID pandemic, hence the limited study sample. They were selected based on them being normotensive and their lack of any comorbidities and any physical disabilities.

After explaining the entire procedure and obtaining informed consent, their baseline vitals were noted and they were made to paddle on a bicycle ergometer at a constant speed (as per a metronome), at a constant resistance, till their heart rate reached a specific value, which for each individual corresponds to his submaximal limit of aerobic exercise, which is expressed by –
50% - 70% of Maximum Heart Rate (Aerobic Limit).

Predicted Maximum Heart Rate (HRmax) = 220 - age.

The subjects were made to paddle continuously for 10 minutes or till their heart rate reached their submaximal limit for aerobic exercise, whichever was later. Their vitals including SBP and DBP were noted at one - minute intervals during the span of exercise and during 10 minutes of recovery after exercise and their response were noted.

The subjects were then questioned by a separate observer (ignorant of their exercise results) about their family history of hypertension according to a standard questionnaire.

Out of 32 sets of data, four were rejected due to faulty technique and erratic response. The remaining 28 sets of data were then grouped and checked by a 2 by 2 Chi square for association.

The data were grouped as -

a) Those having Normal DBP response to exercise with Negative family history of Hypertension.
b) Those having Normal DBP response to exercise with Positive family history of Hypertension.
c) Those having Abnormal DBP response to exercise with Negative family history of Hypertension.
d) Those having Abnormal DBP response to exercise with Positive family history of Hypertension.

Definitions

Normal Diastolic Blood Pressure Response: Elevation of DBP with exercise then fall to resting state or below after 3 - 5 minutes of exercise.

Abnormal/ Exaggerated Diastolic Blood Pressure Response: Sustained elevation of DBP up to 7 minutes of exercise.

Positive family history of hypertension: If any of the first - degree relatives (father, mother, maternal and paternal grandparents) has hypertension.

Negative family history of hypertension: If none of the first - degree relatives has hypertension.

Statistical analyses

Table 1: 2X2 contingency table

	Negative family history of hypertension	Positive family history of hypertension	Row total
Normal DBP response	***a*** **11** **(9.714)**	***b*** **6** **(7.286)**	**17**
Abnormal DBP response	***c*** **5** **(6.286)**	***d*** **6** **(4.714)**	**11**
Column total	**16**	**12**	**n= 28**

The numbers in each box a, b, c and d, outside brackets are the observed outcomes for each group while those inside first brackets in the above 2 by 2 contingency table denote the expected values for each group. Meaning, out of 28 people who took part and exercised in this study, 17 or 17/28 = 60.71% showed normal DBP response and 11 or 11/28 = 39.29% showed abnormal/exaggerated DBP response. Of the subjects in the study, 16 or 16/28 = 57.14% had negative family history of hypertension and 12 or 12/28= 42.86 % had positive family history of hypertension. Now let us

hypothesize that abnormal DBP response to exercise had no relation with positive family history of hypertension. In this case, we would expect 39.29% of the 16 people with negative family history of hypertension (6.286 people) to be having an abnormal/exaggerated DBP response, and 39.29% of the 12 people with positive family history of hypertension (4.714 people) to be having abnormal/exaggerated DBP response. The remaining subjects should be having a positive family history of hypertension. Thus, the expected outcomes are how we would expect the data to look if 16 subjects had negative family history of hypertension and 12 subjects had positive family history of hypertension and 11 subjects had abnormal/exaggerated DBP response, regardless of their family history of hypertension.

Using the information in the Table 1 to compute the $\chi 2$ statistics associated with the data on DBPR to exercise in individuals with positive family history of hypertension. The data outside the brackets are the observed frequencies for that cell, whereas those inside the brackets are the expected frequencies for that cell.

Thus, $\chi^2 = \Sigma$ [(Observed –Expected) ^{2} / Expected]
= { (11 - 9.714) ^{2}/9.714} + { (6 - 7.286) ^{2}/7.286) } + { (5 - 6.286) ^{2}/6.286} + { (6 - 4.714) ^{2}/4.714}
= 0.1702 + 0.2269 + 0.2631 + 0.3508
$\chi^2 = 1.011$

The 2 by 2 Chi square test for our study resulted **$\chi^2 = 1.011$**

The distribution of χ^2depends on the number of treatments being compared. It also depends on the number of possible outcomes. This dependency is quantified in a *degrees of freedom* parameter '*v*' equal to the (number of rows in the table minus 1) times the (number of columns in the table minus 1).
$v = (r - 1) * (c - 1)$

Where r is the number of rows and c is the number of columns in the table. For the 2 X 2 table we have been dealing with, $v = (2 - 1) (2 - 1) = 1$.

Table 2: Critical values for Chi - Square distribution

Percentage Points of the Chi-Square Distribution

Degrees of Freedom	Probability of a larger value of x^2								
	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	0.554	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09
6	0.872	1.635	2.204	3.455	5.348	7.84	10.64	12.59	16.81
7	1.239	2.167	2.833	4.255	6.346	9.04	12.02	14.07	18.48
8	1.647	2.733	3.490	5.071	7.344	10.22	13.36	15.51	20.09
9	2.088	3.325	4.168	5.899	8.343	11.39	14.68	16.92	21.67
10	2.558	3.940	4.865	6.737	9.342	12.55	15.99	18.31	23.21

Thus, from Table 2, it can be seen that the Chi - Square test gives a more than 25% probability of this occurring randomly i. e., Diastolic Blood pressure response to non - isometric exercise is not associated with family history of hypertension in young adults.

4. Result and Discussion

From the study, it was found that the Chi - Square test yielded a result of 1.011, meaning that there was more than 25% probability of this occurring randomly i. e., diastolic blood pressure response to non - isometric exercise is not associated with family history of hypertension in young adults. Hence, an association between the above two could not be established.

This study was conducted to find an association (if any) between isolated abnormal/exaggerated diastolic blood pressure response to non - isometric exercise (cycling) and family history of hypertension i. e., if subjects with family history of hypertension showed abnormal diastolic blood pressure response to the aforesaid exercise due to early onset of atherosclerosis and failure to vasodilate during exercise, thus exhibiting a failure of expected fall of diastolic blood pressure to occur after few minutes of the standardised exercise.

Normal DBPR was standardized to such non - isometric exercise as sustained rise with ongoing exercise, along with rise in HR, SBP up to 6 - 7 minutes of above - mentioned exercise, by which it gradually should fall to resting level and below due to metabolic vasodilatation, and then rise again to resting level during recovery.

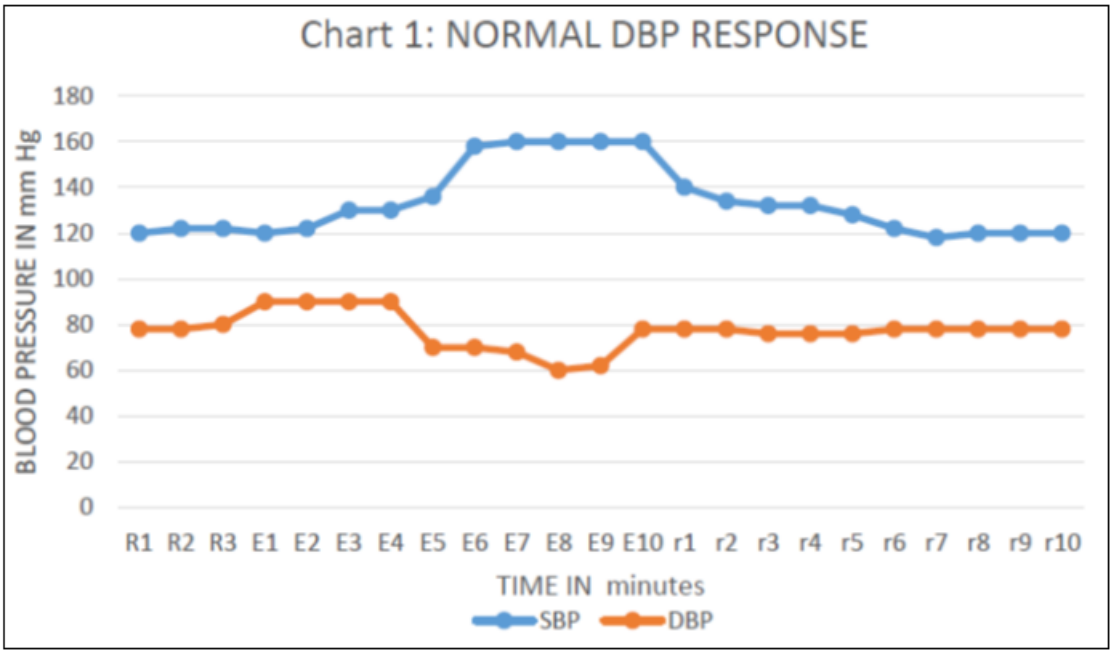

Chart 1 shows a subject's DBPR to the mentioned exercise which is considered as NORMAL DBPR in our study. The x - axis denotes time in interval of 1 minute; R - At Rest, E - During exercise and r - During Recovery. The y - axis denotes changes in Blood Pressure in millimetre of Mercury (mm of Hg). From the chart, we can observe the trend of SBP and DBP during 3 consecutive minutes of rest (R1, R2 and R3), then during 10 minutes of exercise (E1 to E10) and then during 10 minutes of recovery (r1 to r10). It can be seen that from the initiation of exercise at E1, both SBP and DBP rises gradually due to increase in cardiac output. While rise of SBP is steady, DBP rises till 4th minute of exercise (E4) and then gradually drops due to metabolic vasodilatation and then rises again to resting level during recovery.

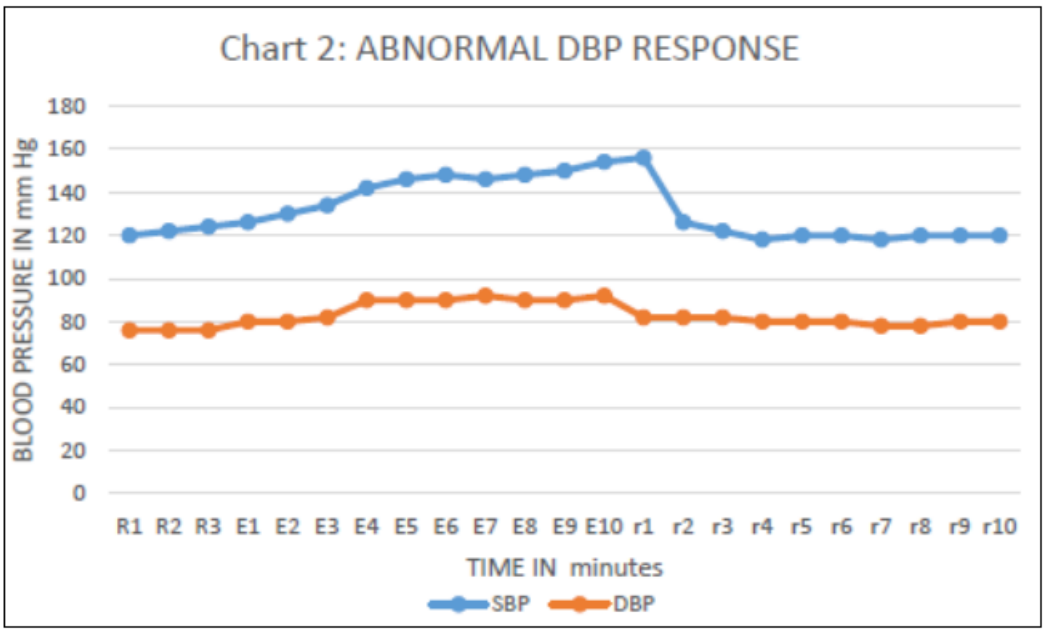

Chart 2 shows a subject's DBP response to the mentioned exercise which is considered as ABNORMAL or EXAGGERATED DBPR in our study. The x - axis denotes time in interval of 1 minute; R - At Rest, E - During exercise and r - During Recovery. The y - axis denotes changes in Blood Pressure in millimetre of Mercury (mm of Hg). From the chart, we can observe the trend of SBP and DBP during 3 consecutive minutes of rest (R1, R2 and R3), then during 10 minutes of exercise (E1 to E10) and then during 10 minutes of recovery (r1 to r10). We can see that SBP rises with exercise from E1 as it should. DBP rises too with exercise as it should normally, but here it fails to fall even after 7 minutes of exercise. Possible reason could be failure to vasodilate metabolically.

Exaggerated SBPR to exercise has already been associated with future risk of hypertension in several studies.

Also, family history of hypertension is a proven predictor of future risk of hypertension.

However, isolated abnormal/exaggerated DBPR to exercise might not have been vastly studied in association to future risk

of hypertension. To find such an association, a long - term prospective study was called for.

Of the 28 subjects, n=28, I had (a) Those having Normal DBPR to exercise with Negative family history of Hypertension. (b) Those having Normal DBPR to exercise with Positive family history of Hypertension. (c) Those having Abnormal DBPR to exercise with Negative family history of Hypertension. (d) Those having Abnormal DBPR to exercise with Positive family history of hypertension, where a=11, b=6, c=5, d=6. So, out of n=28, a+c=16 subjects were having negative family history of hypertension, while b+d=12 subjects had positive family history of hypertension. a+b= 17 subjects showed normal DBPR to exercise, while c+d=11 subjects showed abnormal/exaggerated DBPR. Considering 17 subjects showed normal DBP response, 11 of them did not have any family history of hypertension, which should be a normal occurrence. And out of 11 subjects with abnormal DBPR, 6 had positive family history of hypertension, which is inconclusive.

Hence, it was found that there was more than 25% probability of randomness i. e., DBPR to non - isometric exercise is not associated with family history of hypertension in young adults. Hence, it is clear that an association between the above two could not be established. From this study, it can be said that both abnormal/exaggerated DBPR and positive family history of hypertension are predictors of future hypertension but there is no association between them.

Due to the ongoing COVID pandemic during my study period, the proposed sample size could not be completed and I had to complete my study on n=28 subjects whose data were collected prior to the onset of pandemic. A bigger sample size could have reflected a clearer and more definitive result.

5. Conclusion

I had conducted a cross sectional, analytical study to check for association between Diastolic Blood Pressure response (DBPR) to non - isometric exercise and familial history of hypertension in 32 young, healthy (without any comorbidities), sedentary (or casually involved in sports) adults, out of which 28 sets of data were considered for the study. Data from 4 subjects were discarded due to faulty recording. Then, the data was compiled in a 2 by 2 contingency table and Chi - square test was applied.17 subjects showed normal DBP response, 11 of them did not have any family history of hypertension, which should be a normal occurrence. And out of 11 subjects with abnormal/exaggerated DBPR, 6 had positive family history of hypertension, which was inconclusive. The test gave us a more than 25% chance of randomness of association between abnormal/ exaggerated DBPR and positive family history of hypertension, which refuted the association. Thus, abnormal/ exaggerated DBPR to non - isometric exercise and family history of hypertension can both be predictors of future hypertension but there is no association between them according to our study. Future studies with a bigger sample size and with prospect of follow up for development of hypertension could provide more insight on this aspect.

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