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A Cross-Sectional Study of Sympathetic Response in Young Normotensive Indian Population

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Abstract

Background and Objectives: Cardiovascular disease (CVD) risk has long been associated with sympathetic activation, with a notable gender difference in its incidence, favouring women over men. However, the influence of gender on sympathetic response has remained a topic of investigation. The primary objective of our study was to examine whether there is a gender disparity in sympathetic response.

Materials and Methods: We conducted a study involving 200 study subjects whose age and BMI matched, 102 females, and 98 males aged 17-22 years. We recorded the response to cold pressor test and isometric handgrip tests to assess sympathetic haemodynamic response in the study subjects.

Results: Women demonstrated lower sympathetic reactivity to both cold pressor and isometric handgrip tests compared to men. These differences were statistically significant (p value < 0.05).

Conclusion: Women have lower sympathetic reactivity compared to men. These differences stem from variations in central and reflex control mechanisms, as well as reduced vasoconstrictor responsiveness. These findings may contribute to the lower incidence of cardiovascular events in women compared to men, shedding light on the intricate relationship between gender and cardiovascular health.

Key Words: Sympathetic Response, Handgrip test, Cold pressor test, Blood pressure, Heart rate.

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Introduction

Laboratory stress tests have been utilized as a research approach to explore cardiovascular reactivity in individuals with both normal blood pressure and hypertension [1-3]. Carroll et al. conducted a study in which they investigated the hemodynamic reactions to psychological stress. They found that individuals who exhibited heightened blood pressure reactivity were at an elevated risk of subsequent cardiovascular disease-related mortality [4].

These laboratory stressor tests can be categorized into two primary types. One category involves assessing the emotional response of individuals, exemplified by tests like the mental arithmetic stress test [4] and the Stroop conflict color-word test [5-7]. The second category comprises stressors that induce physical stimuli, such as the isometric handgrip test [6, 8] and the cold pressor test [1, 9]. Additionally, laboratory stressors have been further divided into passive coping stressors (e.g., the cold pressor test) and active coping stressors (e.g., the Stroop test), based on the tasks assigned to subjects [10].

It is widely recognized that laboratory stressors lead to an elevation in blood pressure and heart rate, with the magnitude of hemodynamic responses being greater in individuals with cardiovascular conditions compared to healthy individuals [2, 11, 12]. Nevertheless, there exists a deficiency in standardized criteria for categorizing hyper reactivity to stressor tests.

Hemodynamic reactivity to both psychological and physical stressors has been assessed in healthy individuals [2, 3, 13-16]. Comprehensive reviews of cardiovascular reactivity to stressor stimuli have been conducted in meta-analyses [17-19]. Researchers have also explored the association between a family history of cardiovascular diseases and cardiovascular responses to stress [14, 19, 20]. Despite the existing body of literature, there is a need for additional research into the variability of hemodynamic responses to stressor tests in healthy individuals, comparisons among traditional stressor tests, and how these responses are influenced by gender. Therefore, the objective of the current study was to assess pressor responsiveness to physical stressors in normotensive subjects, with a specific focus on exploring whether gender influences these responses.

Material and Methods

A total of 200 young adult subjects (102 females, and 98 males) voluntarily participated in the study. They were carefully matched for age and body mass index (BMI). Informed consent was obtained from participants.

Inclusion and Exclusion Criteria:

Participants eligible for inclusion were those who provided written informed consent, were aged 17–22 years, were right-handed (for uniformity), and were categorized as normotensive as per JNC VII guidelines [21]. Exclusion criteria encompassed individuals who were underweight (BMI <18.5) or overweight (BMI >24.99), were on medication affecting blood pressure or autonomic functions, followed any yoga/exercise/diet regimen, had metabolic disorders such as diabetes mellitus or thyroid disorder, had cardiovascular or neuropsychiatric disorders, suffered from known illnesses impacting the autonomic nervous system, were smokers, and/or alcohol consumers.

Upon obtaining written informed consent and recording participant details, height, weight, and resting heart rate and resting blood pressure (BP) were measured using standard protocols. All measurements were conducted between 9.30 am and 11.00 am in a dedicated examination

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room. Participants were required to abstain from consuming coffee, tea, or cola for 12 hours before the experiment and were allowed a light breakfast 2 hours prior. The examination room was maintained at a temperature between 23 and 25°C. Participants had one hour to adapt to the experimental and environmental conditions, during which detailed history taking and physical examinations were performed.

Resting Heart Rate: Participants lay comfortably for approximately 15–20 minutes, and heart beats were auscultated using a standard stethoscope and counted for one full minute. An AVerage of thrre such readings was taken as the resting heart rate.

Resting BP Measurement: Participants were instructed to sit comfortably in a chair with their feet on the ground, while their arms were supported at heart level, for at least 5 minutes. Systolic BP (SBP) and diastolic BP (DBP) were measured using a mercury sphygmomanometer (PERFECT, India). An average of three such measurements was calculated as the resting BP [21].

BMI Calculation:

BMI was calculated using the formula: BMI = Weight (in kg) / Height^2 (in m^2) [22]

Mean Blood Pressure (MBP): MBP was calculated using the formula MBP = Diastolic BP + 1/3 Pulse Pressure.

Sympathetic Reactivity Tests:

Two sympathetic reactivity tests were conducted to assess cardiovascular responses to specific stimuli:

1. BP Changes to Isometric Exercise (Hand Grip Test): Participants sat comfortably, and BP measurements were taken at regular intervals to ensure consistent readings. Isometric exercise was initiated using a hand grip dynamometer. Initially, the subject maximally gripped the dynamometer with their dominant arm (all participants were right-handed). Three successive trials were performed, and the highest value was recorded as the maximum voluntary contraction (MVC). After a 5-minute interval, participants performed hand grip exercises, sustaining them steadily at 30% MVC for a minimum of 2 minutes. Throughout this procedure, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded at 30-second intervals using a mercury sphygmomanometer on the non-exercising arm. The maximum increase in SBP and DBP during this exercise was considered the reactivity index. BP was monitored until it returned to normal levels after exercise.

2. BP Changes to Cold Stimulation (Cold Pressor Test [CPT]): Participants were seated comfortably, and BP readings were taken at regular intervals to establish a baseline. The CPT commenced after consistent BP readings were recorded. Participants were instructed to submerge their hand in a container filled with ice-cold water, maintaining a water temperature of 4–6°C throughout the test, as monitored by a mercury thermometer. SBP and DBP were measured in the other arm at 30-second intervals during a 2-minute period while the hand was submerged. After 2 minutes, participants were allowed to remove their hand, and a towel was provided for rewarming. Throughout the procedure, participants were reassured. The maximum increases in SBP and DBP in response to cold stimulation were recorded. BP measurements continued until they returned to normal levels after the test.

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Data Analysis:

The collected data were entered into MS Excel 2010 and analyzed using SPSS (Statistical Package for the Social Sciences), version 20. Statistical analysis was performed using the unpaired Student's t-test to compare the means of various parameters between the male and female groups. A significance level of $P < 0.05$ was considered statistically significant.

Results

Table 1 displays the anthropometric parameters of all study participants. There was no difference in these parameters when compared gender wise.

Table 1: Anthropometric parameters of study population

Parameter	Females (n=102) Mean ± SD	Males (n = 98) Mean ± SD	p Value
Age (in Years)	20.15 ± 1.89	19.28 ± 1.63	0.73
Height (in Centimetres)	159.2 ± 3.95	160.72 ± 4.42	0.41
Weight (in Kg)	59.02 ± 3.79	61.89 ± 4.12	0.67
BMI (Kg/m2)	24.88 ± 2.28	23.95 ± 2.01	0.58

Table 2 displays the resting cardiovascular characteristics of the participants in the study. It is worth noting that there were no statistically significant distinctions in these parameters between males and females.

Table 2: Resting cardiovascular variables of the study participants

Parameter	Females (n=102) Mean ± SD	Males (n = 98) Mean ± SD	P value
R-HR (bpm)	83.00 ± 4.50	82.75 ± 5.00	0.91
R-SBP (mmHg)	118.50 ± 8.00	120.11 ± 8.20	0.83
R-DBP (mmHg)	77.50 ± 4.70	80.57 ± 4.60	0.65
R-MBP (mmHg)	92.34 ± 3.00	93.75 ± 3.20	0.79

Table 3 displays the assessment of sympathetic reactivity to physical stressors using the cold pressor and hand grip tests among the study participants. It was observed that females exhibited notably reduced sympathetic reactivity in response to these tests in comparison to males.

Table 3: Sympathetic reactivity to physical stressors in the study participants

Parameter (Post-test minus Pre-test value)	Females (n=102) Mean ± SD	Males (n = 98) Mean ± SD	P value
SR-C (mmHg)	17.20 ± 5.45	21.10 ± 9.23	<0.05
DR-C (mmHg)	15.50 ± 4.90	18.70 ± 5.65	<0.05
SR-H (mmHg)	18.40 ± 4.60	22.30 ± 9.10	<0.05
DR-H (mmHg)	14.90 ± 5.60	18.20 ± 5.75	<0.05

SR-C: Systolic blood pressure reactivity to cold pressor test, DR-C: Diastolic blood pressure reactivity to cold pressor test, SR-H: Systolic blood pressure reactivity to handgrip dynamometry test, DR-H: Diastolic blood pressure reactivity to handgrip dynamometry test

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Discussion

In our study involving 200 healthy participants, we found that both the Hand grip and cold pressor tests led to increases in blood pressure (BP). Notably, our data indicated that males experienced more significant increases in BP compared to females during all the stressor tests. Furthermore, males were more prone to exhibit exaggerated pressor responses during the handgrip test.

These gender disparities in cardiovascular reactivity to stress were anticipated, given the protective effects of estrogen. Estrogen typically results in a decreased manifestation of cardiovascular disease risk factors in premenopausal women when compared to men [23]. Our observations revealed that females had lower elevations in BP in response to the stressors. This finding aligns with previous research that demonstrated women having reduced BP responses during both a static handgrip test [24, 25] and the cold pressor test [25].

The handgrip exercise is known to induce increases in both BP and heart rate, as indicated by numerous studies [26-28]. Brorson et al. [29] reported that handgrip exercises performed at 30% of maximal voluntary contraction (MVC) result in elevated SBP and diastolic blood pressure DBP levels in both individuals with normal blood pressure and those with hypertension. Aoki et al. [30] observed that handgrip exercise tends to raise BP, particularly in individuals with borderline hypertension. In our investigation, we also confirmed that handgrip exercise led to an elevation in BP among normotensive participants.

The CPT has been shown to raise BP in healthy individuals [31-33]. During the initial phase of this test, cardiac output increases with only a minor increase in sympathetic nerve activity in the muscles. However, in the later phase of the test, this activity rises, resulting in increased peripheral resistance. Additionally, pulse pressure mainly increases towards the end [34]. Our findings align with these observations, as we observed an increase in BP response to CPT among healthy individuals. These results are consistent with numerous prior studies [35-37].

Those who exhibit hyperreactivity to physical stressors, especially with a sluggish recovery rate, may be at a higher risk of developing essential hypertension later in life [38]. Zbrozyna et al. [39] proposed that young individuals with hypertension may not adapt well to persistent renal vasoconstriction triggered by the cold pressure test, resulting in an exaggerated increase in BP during the test.

Conclusion

The significance of these gender-related differences in sympathetic reactivity extends beyond the realm of scientific curiosity. It has important implications for cardiovascular health. The lower sympathetic reactivity in women may contribute to their generally lower incidence of cardiovascular events compared to men. This observation underscores the complex interplay between gender and cardiovascular health, shedding light on potential avenues for research and intervention aimed at understanding and mitigating cardiovascular risk factors in both men and women.

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