

**Original article**

## **Gender Differences in Cardiovascular Response to Sustained Isometric Contraction in Young Healthy Subjects: An interventional study**

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### **Abstract**

**Introduction:** The sustained isometric muscle contraction is a useful method to assess cardiac function. The cardiovascular response is varied in male and females as they have different anatomical, physiological and hormonal aspects. So in the present study, the gender difference in cardiovascular response to sustained isometric contraction was studied.

**Methods:** This study was a community based interventional study for which 150 males and 150 females of age group 18-25 years were taken on 30 cluster sampling technique from the population of the municipal area of Jaipur. The cardiovascular response variables, the heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded before and after the isometric exercise by handgrip dynamometer.

**Observations and results:** All cardiovascular parameters were found raised significantly in males and females after the isometric contraction, except SBP that shows non- significant effect in males. When the effect of isometric exercise was compared in males with females then the effect was found non-significant, except HR where it was found significantly more in males.

**Conclusion:** All cardiovascular parameters were raised significantly after the sustained isometric contraction in both genders, but the less mean change was found in females than males that reveals females are more cardio-protective.

**Keywords:** Isometric contraction, Cardiovascular response, Gender

### **Introduction**

Cardiovascular diseases are the largest cause of death worldwide except Africa.<sup>(1)</sup> It is estimated that 60% of the world's cardiovascular disease burden will occur in the South Asian subcontinent/India despite only accounting for 20% of the world's population. This may be secondary to a combination of genetic predisposition and environmental factors.<sup>(2)</sup> The high blood pressure is a major risk factor for various cardiovascular diseases. Worldwide raised blood pressure is estimated to cause 7.5 million deaths, about 12.8% of the total of all deaths. The raised blood pressure is related to the risk of stroke, coronary heart disease, and peripheral vascular disease, renal and visual impairment. Approximately half of these deaths will occur in young and middle-aged individuals, making the impact on society and the economy even more significant.<sup>(3)</sup> In all WHO regions, men have a slightly higher prevalence of raised blood pressure than women.<sup>(4)</sup>

The beneficial effect of exercise on the cardiovascular system is well documented. Physical activity enhances person's health and wellness. Sustained exercise increase cardiac output in demand to the requirement of oxygen to exercising muscle. The mechanisms by which the cardiac output is increased during exercise may differ between men and women due to the anatomical and physiological difference. Other factors may also modify the cardiovascular response to exercise include the phase of the menstrual cycle, age, exercise mode, length of the exercise session, and environmental of exercise such as heat stress etc. Compared with healthy young men, healthy young women appear to be protected from high blood pressure by the vasodilator activity of estrogens; women are also reported to possess less sympathetic influence on their cardiovascular system than men.<sup>(5,6,7)</sup> Though some physiological difference in male and female that may cause a change in cardiovascular response to the sustained isometric contraction that is yet to be studied.

There are abundant studies on aerobic exercise on cardiovascular health, albeit less literature is documented to describe the cardiovascular effect on static muscular contraction in normal adolescents of the different gender. A non-invasive procedure using hand grip dynamometer to observe cardiovascular responses to sustained isometric exercise was taken in the present study.

**Aims & Objectives:** The present study hypothesizes to compare the effect of isometric exercise on cardiovascular parameters in males and females.

**Material & Methods:**

The present community-based interventional study was conducted in the Department of Physiology, SMS Medical College, Jaipur (Rajasthan). The study was conducted after taking clearance from the institutional ethical committee.

For the study purpose, 300 untrained apparently healthy adults (150 males and 150 females) in the age group of 18-25 years were taken from municipal areas of Jaipur using 30 cluster sampling technique. Participants were interrogated after taking well-informed written consent. Those subjects having any acute or chronic diseases or disease interfering with the autonomic nervous system were excluded from this study. The alcoholics, smokers and tobacco chewers, subjects doing any regular exercise, obese, malnourished and taking drugs that interfere with the Autonomic Nervous System and the non-cooperative subjects were also excluded from this study

**Instrumentation:** The Alpha handgrip spring dynamometer was used for performing isometric contraction. The mercury sphygmomanometer was used to measure the blood pressure of the study participants. The weighing machine and height measuring instrument were used to calculate the BMI.

**Procedure:** First body weight was recorded in kilograms on an empty bladder and before lunch, wearing lightweight clothing and barefoot with weighing machine. Standing height was also recorded in meters. Then the BMI was calculated using Quetelet's index:  $BMI = \text{Weight (in Kg)} / \text{Height}^2 \text{ (in meters)}$ . The systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured as outcome measures in the non-exercising arm using a mercury sphygmomanometer. The mean arterial pressure (MAP) was calculated as  $MAP = DBP + 1/3(SBP-DBP)$ .

The sustained isometric contraction was performed by using handgrip spring dynamometer. The subject was asked to sit comfortably in a chair for five minutes and then the test procedure was explained. The subject was instructed not to perform a Valsalva manoeuvre during the exercise period. The baseline HR and BP were recorded. Then the subject was asked to hold the handgrip dynamometer using maximum effort with their dominant hand for few seconds with closed eyes. The value was noted & the procedure was repeated thrice. The

maximum value of the three readings was taken as the maximal voluntary contraction (MVC). Then a mark was made on the dynamometer at 30% of MVC of the subject and then the subject was asked to maintain the sustained grip on the dynamometer up to the mark with uniform intensity for the 3 minutes. Just before the release of grip, the outcome measures HR and BP (both systolic and diastolic) were recorded and the MAP was calculated.

The Rate pressure product is a useful index of the cardiac stress to predict myocardial oxygen consumption during rest and exercise. Rate pressure product allows you to calculate the internal workload or hemodynamic response. The Rate pressure product is evaluated by this formula.

$$RPP = SBP \times HR^{(8,9)}$$

**Statistical Analysis:** The data collected were analysed using primer (version 6) statistical software. The dependent cardiovascular response variables of interest were HR, SBP, DBP, MAP and RPP. The results were expressed by mean  $\pm$  SD. The statistical significance of difference within the group (pre and post-exercise) was evaluated by paired 't-test' and between the group (male and female) was determined by unpaired 't-test'. The significance level was set at  $P < 0.05$  (as 95% confidence interval).

**Observations and Results**

Mean age of study population was  $20.76 \pm 2.42$  yrs for males and  $20.9 \pm 2.28$  yrs for females. Mean BMI for males was  $20.96 \pm 3.28$  Kg/m<sup>2</sup> and for females was  $20.29 \pm 3.14$  Kg/m<sup>2</sup>. So both groups i.e. males and females were comparable in terms of age ( $p = 0.606$ ), BMI ( $p = 0.072$ ) and Socio economic status ( $p = 0.074$ ).

The cardiovascular parameters, HR, SBP, DBP, MAP and RPP were found significantly raised by sustained isometric exercise in case of females. (Table 1)

**Table no. 1**  
**Effect of isometric contractions on cardiovascular response in females**

S. No.	Parameters (n=150)	Pre exercise	Post exercise	t	p	Significance
1	HR (beats/min.)	87.53 $\pm$ 11.87	89.73 $\pm$ 12.55	3.3774	0.0009	HS
2	SBP (mm Hg)	110.65 $\pm$ 12.12	111.93 $\pm$ 13.44	2.0462	0.0425	S
3	DBP (mm Hg)	74.67 $\pm$ 9.60	77.69 $\pm$ 11.90	5.089	0.0001	HS
4	MAP (mm Hg)	86.66 $\pm$ 9.93	89.06 $\pm$ 11.91	4.584	<0.0001	HS
5	RPP(mmHg*bpm)	9727.04 $\pm$ 1946.28	10104.11 $\pm$ 2187.67	3.57	<0.0001	HS

HS=Highly Significant S=Significant

Whereas in case of males all the cardiovascular parameters that are HR, SBP, DBP, MAP and RPP were found significantly raised except HR by sustained isometric exercise. (Table 2)

**Table no. 2**

**Effect of isometric contractions on cardiovascular response in males**

S. No.	Parameters (n=150)	Pre exercise	post exercise	t	p	Significance
1	HR (beats/ min.)	84.47±12.05	89.15±13.25	7.1819	<0.0001	HS
2	SBP (mm Hg)	128.26±13.01	139.95±81.66	1.7562	0.0811	NS
3	DBP (mm Hg)	81.81±10.98	85.69±10.89	3.9285	0.001	HS
4	MAP (mm Hg)	97.424±10.68	101.53±11.33	4.7953	<0.001	HS
5	RPP(mmHg*bpm)	10879.71±2177.39	12675.93±7521	2.99	0.003	HS

HS=Highly Significant NS=Non-Significant

When mean change (post-exercise values deducted from pre-exercise values) of various cardiovascular variables like HR, SBP, DBP, MAP and RPP were compared between males and females, less mean change was observed in females than males with high significance difference was only observed in heart rate. This shows females are less prone to any cardiovascular risk due to sustained isometric type of resistant stress (Table no. 3, figure no. 1)

**Table no. 3**

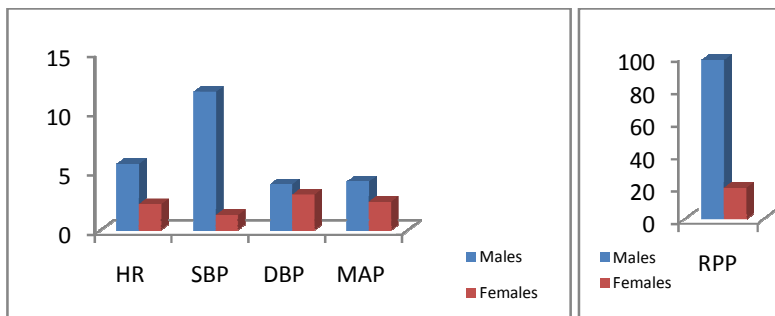
**Mean change (after-before exercise) in various cardiovascular parameters in males and females**

S. No.	Parameters (mean change)	Males (mean ±SD)	Females (mean ±SD)	t	p	Significance
1	HR (beats/ min.)	5.60±9.69	2.20±8.00	3.314	0.001	HS
2	SBP (mm Hg)	11.68±81.50	1.28 ±7.6	1.556	0.121	NS
3	DBP (mm Hg)	3.88±12.09	3.01±7.25	0.756	0.450	NS
4	MAP (mm Hg)	4.11±10.50	2.40±6.41	1.702	0.090	NS
5	RPP(mmHg*bpm)	98.02±581	19.28±64.88	1.65	0.100	NS

HS=Highly Significant NS=Non-Significant

**Figure no. 1**

**Mean change (after-before exercise) in various cardiovascular parameters in males and females**



## Discussion

The present study hypothesizes to observe and compare the effect of isometric exercise on cardiovascular health in different gender in term of HR and BP. All the cardiovascular parameters as HR, SBP, DBP, MAP and RPP are raised significantly in both sexes, after sustained isometric contraction, except SBP in males. However, when the mean change (post-pre exercise) in cardiovascular parameters is compared in both genders, all variables are less elevated in females than males with the statistically significant difference in heart rate (table 3).

Post-exercise cardiovascular parameters are significantly increased without gender bias, except SBP in males. Misner et al<sup>(10)</sup>, alike to the present study found similar heart rate response in both sex to static exercise, but SBP response differs from our study. F.A. Maruf et al<sup>(11)</sup> observed that adjusted resting SBP, resting HR, BMI and exercise duration, all cardiovascular variables no longer showed the significant difference between males and females. Their findings suggest that sex does not influence SBP and HR responses to dynamic exercise in healthy young adults. These findings are not according to our study as in this study female shows less change in cardiovascular parameters.

Mbada C.E. et al<sup>(12)</sup> found that baseline cardiovascular parameters were not significantly different between the male and the female participants. However, the post-exercise SBP and RPP were significantly different between the male and the female participants, respectively. The male participants had a higher post-exercise SBP level than the females while the females had a higher post-exercise RPP level than the males. While in the present study males have a high change in SBP, DBP and RPP but with a non-significant difference, while females have less change in all cardiovascular parameters with high significance difference in heart rate. Bhavsar et al etc (2015)<sup>(13)</sup> found post-exercise cardiovascular parameters were significantly greater ( $p < 0.05$ ) than baseline values without gender bias, that is consistent with our finding. Our study is also comparable to Kodzo et al (2013)<sup>(14)</sup> they found no significant gender difference ( $p > 0.05$ ) in the cardiovascular parameters of the participants following handgrip exercise, except a change in HR.

In our study females are more cardioprotective to isometric type of exercise as depicted by less mean changes in cardiovascular parameters (HR, SBP, DBP, MAP and RPP) as compared to males, consistent with other studies that reveals that in females lesser change in cardiovascular variables are due to vasodilator effect of estrogen on blood vessels and moreover, women are also reported to possess less sympathetic influence on their cardiovascular systems than men.<sup>(5,6,7)</sup>

Our study is satisfactory because we include healthy young adults that are within normal BMI (males  $20.96 \pm 3.28$ , females  $20.29 \pm 3.14$ ,  $p = 0.072$ ) so the effect of isometric exercise on BP and HR is due to the effect of sex, not of other variables. We also observe the effect of isometric exercise on SBP in females is significant than the males, but the mean change in SBP is more in males than females with a non-significant difference. The mean change in DBP in both genders is less raised with non-significant effect. The RPP is a good predictor of internal workload on myocardial muscles or shows the hemodynamic response of the heart. The present study males have a slightly higher hemodynamic response than females, but within low limits, shows less energy consumption by heart during sustained isometric contractions.

Isometric type of exercise is performed at many places eg: in the household, occupational settings, sports and recreational activities. In the static exercise, both systolic and diastolic pressures are increased markedly, so also the mean arterial pressure.<sup>(15,16)</sup> As in any muscular work, static exercise also increases metabolic demands of the active muscle. During static work, high intramuscular tension causes mechanical constriction and so

thereafter impedes blood flow to the exercised muscle. So by reduced blood supply, the metabolites are accumulated at the site of static muscle contraction. These accumulated metabolites [H<sub>2</sub>O, adenosine diphosphate (ADP), and others] stimulate sensory nerve endings, which leads to a pressor reflex, causing a rise in mean arterial pressure (pressor response). This raised blood pressure is substantially larger than the increase in aerobic exercise requiring similar energy expenditure.<sup>(17)</sup> Total peripheral resistance (TPR) decreases during static exercise, although not to the extent seen in dynamic aerobic exercise. The high blood pressure generated during static contractions helps overcome the resistance to blood flow due to mechanical occlusion. Because systolic blood pressure and heart rate both increase during static exercise, there is a large increase in myocardial oxygen consumption and thus rate-pressure product.

**Limitations:**

Blood pressure adaptations during sustained isometric contraction may be through alterations in the activity of nitric oxide synthase, arachidonic acid-derived lipoxygenase metabolites, increased density of capillaries and venules and sympathetic nervous system modulation, and probably other mechanisms<sup>(18,19,20)</sup> may be important targets of future research.

In the present study, sympathetic insufficiency is tested only by sustained isometric contraction apart from another test like sympathetic skin response, cold pressure response, blood pressure response to standing, heart rate variability also be important for validating our results.

**Conclusion:**

So it can be concluded that the significant effect of sustained isometric contraction on cardiovascular variables was observed in both genders, but in females, less mean change was found as compared to males that reveal females are more cardio-protective.

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