Gender differences in cardiovascular responses to isometric exercise

Srikanth S, NagaTeja D' Pragathi BH

ABSTRACT

Background: Static exercise causes cardiovascular strain, which forms the basis for prediction and prevention of excessive cardiac load in a normal person. At any level of physical activity, exercise training increases cardiovascular functional capacity in healthy persons and in person's with cardiovascular disease.

Aim: To test the cardiovascular strain due to static exercises.

Methods: The study was performed on randomly selected healthy male and female subjects of age 18-25 years (30 male and 30 female). Heart rate and Blood pressure were recorded at rest and after 30 seconds of isometric exercise both in seated and supine positions.

Results: Mean arterial pressure (MAP), systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) increased in parallel for both genders in all trials. Men had significantly greater value than women across experimental conditions for several of the cardiovascular measurements: MAP (109.56 vs. 103.33 mmHg), SBP (127.26 vs. 124.06 mmHg), and DBP (99.46 vs. 93.6 mmHg): HR (81.63 vs 76.6). When data for genders was combined, cardiovascular variables were significantly greater in the seated position compared to supine position.

Conclusion: The findings of our study show that cardiovascular and hemodynamic responses to isometric handgrip exercise differ by gender and posture does affect cardiovascular responses to isometric exercise.

Keywords: isometric exercise; heart rate; blood pressure.

INTRODUCTION

Isometric exercises produce cardiovascular response that differs significantly from the responses during dynamic exercise. Various factors like age, sex, type of activity and training were implicated which effect the sympathetic as well as pressure response to physical exercise. Previous studies which were conducted in young trained athletes have shown a lower sympathetic and hemodynamic response to the isometric exercise and that was accompanied with improved cardiac performance.[1] Exercise training increases cardiac functional capacity and decreases oxygen demand of myocardium in healthy persons as well as in person's with cardiovascular disease. Exercise Training is considered to reduce both adrenergic and pressure response to exercise.

Changes in autonomic regulation have been demonstrated after physical training in sedentary individuals in a study, which explored the relationship between physical training and Heart Rate Variability (HRV).[2] It reported that the training leads to bradycardia, a decrease in the Low Frequency component and an increase in the High Frequency component of Heart rate. It was suggested previously that after isometric training, change in sympathetic neural influences on total vascular resistance lead to a decline in blood pressure (BP).[3] The increase in blood pressure response was mediated by alterations in autonomic nervous system activity. Other mechanisms such as increased muscle blood flow, decreased muscle sympathetic nerve activity and baroreceptors resetting were also implicated in the attenuated response in BP.[4,5] Heart rate which increase immediately after the beginning of light static exercise is higher than the increase in oxygen uptake. In addition the systolic and diastolic BP increases immediately in the beginning of the exercise and increase slowly during the work period. When this data was compared with that of the corresponding responses to equal mild dynamic exercise, heart rate and the B.P were higher during static exercise.[6]

Physical exercise is characterized by increase in arterial BP, heart rate and cardiac output. The appropriate cardiovascular responses to exercise are largely accomplished by changes in autonomic nervous system activity.[7] Rowell LB suggested that from the onset of exercise, neural input from central command acts on the central neuron pool, receiving baroreceptor afferents to reset the arterial baroreflex.[8]

MATERIALS AND METHODS

The study was performed on randomly selected sixty healthy individuals in the age group 18-25 years (30 male and 30 female). This study excludes the individuals who are Hypertensive (BP >140/90mmHg), Obese, Athletes, Body builders or with any cardiac abnormalities. The personal history of each individual was recorded and was informed about the objectives and goal of the study. The procedure to be adapted was explained and the consent was taken from each individual. The height and weight were recorded for each individual in meter and kilogram respectively.

Heart Rate was recorded by counting the pulse rate by palpation of the radial artery. The participant is allowed to sit on a chair for recording of BP and heart rate at rest and was allowed for performing isometric exercise after giving proper instructions and then BP and heart rate were recorded after 30 seconds of exercise and were instructed to lie flat in supine position on a bed and procedure is repeated as in seated position. For calculating the Maximum Voluntary Contractions (MVC) in Isometric exercise, Isometric Hand Grip Dynamometer (Inco, Ambala) was used. All the subjects were able to complete 2 minutes of exercise but none exceeded 4 minutes.

The statistical analysis was performed using Graph Pad Prism – 5.0 Version. As the analysis is done between the groups, UNPAIRED T – TEST was used.

RESULTS

Table. 1. Mean PR, SBP , DBP, MAP in Male's Seated and Supine during Rest and Exercise

	MSe-REST	Mse-EXERCISE	MSu-REST	MSu-EXERCISE
PR (beats S/min)	76.6 ± 5.163	81.63 ± 4.89	74.17 ± 5.73	77.9 ± 5.04
BPmmHg	124.06 ± 8.57	127.26 ± 23.1	119.66± 9.38	126.26 ± 8.65
DBPmmHg	93.6 ± 7.81	99.46 ± 8.35	90.46 ± 7.74	95.33 ± 9.32
MAPmmHg	103.33 ± 6.87	109.56 ± 7.54	100 ± 6.78	105.6 ± 8.22

MSe - Male Seated ; MSu - Male Supine

Table. 2. Mean PR, SBP , DBP, MAP in Female's Seated and Supine during Rest and Exercise

	FSe-REST	FSe - EXERCISE	FSu-RESTF	Su-EXERCISE
PR (beats/min)	69.46 ± 5.74	73.6 ± 5.67	67.8 ± 5.45	70.23 ± 5.47
SBP mmHg	112.33 ± 7.73	119.33 ± 9.42	107.13 ± 7.80	114.06 ± 9.26
DBP mmHg	82 ± 5.48	87.86 ± 5.82	79.26 ± 6.87	82.33 ± 6.68
MAP mmHg	91.73 ± 4.77	98.06 ± 5.57	87.86 ± 5.45	92.96 ± 6.60

FSe – Female Seated FSu – Female Supine

In seated position under resting conditions, the difference in the mean pulse rate between male and female subjects was 10.2 and in seated position after exercise, it was 8.03 (p value < 0.0001). The difference in the mean SBP in seated position under resting conditions between male and female subjects was 11.73 mmHg (p < 0.0001) while in seated position after exercise it was 7.93 mmHg. The difference in the mean DBP in seated position under resting conditions between male and female subjects was 11.6 mmHg while in seated position after exercise it was 11.6 mmHg (p value < 0.0001). The difference in the MAP in seated position under resting conditions between male and female subjects was 11.6 mmHg while in seated position after exercise it was 11.5 mmHg (p value < 0.0001).

The difference in the mean Pulse rate in supine position under resting conditions between male and female subjects was 6.36 while in supine position after exercise between it was7.67 (p value < 0.0001). The difference in the mean SBP in supine position under resting conditions between male and female subjects was 12.53 mmHg while in supine position after exercise it was 12.2 mmHg (p value < 0.0001). The difference in the mean DBP in supine position under resting conditions between male and female subjects was 11.2 mmHg while in supine position after exercise it was 13 mmHg (p value < 0.0001). The difference in the MAP in supine position under resting conditions between male and female subjects was 12.14 mmHg while in supine position after exercise it was 12.64 mmHg (p value < 0.0001).

SBP, DBP, MAP and HR increased in parallel for both genders throughout all trials. Men had significantly greater values than women across experimental conditions for several of the cardiovascular measurements. When data for genders was combined, cardiovascular variables were significantly greater in the seated compared to supine posture.

DISCUSSION

Zidermanis A found that the concentric phase of muscle action compresses peripheral arteries with increase in cardiac after load which decreases the venous return, which further increases Systolic and Diastolic pressure. The rapid increase in the blood pressure was caused by sustained contraction of approximately 20% of Maximum Voluntary Contraction.[9] Ehsani AA et al, observed that heart rate and blood pressure increased significantly during each level of isometric exercise and higher levels of Isometric exercise enhance left ventricular performance, also with a sudden increase in blood pressure.[10]

Lind AR et al, reported that throughout sustained hand-grip contractions at tensions above 15% MVC, the heart rate, blood pressure, cardiac output all increased in a linear fashion in healthy young men.[11] Cembada, OA et al,. determined the cardiovascular responses to upper extremities isometric exercise. Post exercise systolic blood pressure and rate pressure product were different in men and women.[12] Charles L Stebbins et al studied cardiovascular responses to static and dynamic contractions during comparable workload in humans. They found larger increase in blood pressure and heart rate which occurred during dynamic contraction by increasing peak tension is due to greater stimulation of mechanoreceptors and enhanced activation of central command.[13] Cheri L McGowan et al investigated improved systemic endothelial function as a mechanism of arterial BP modification, following isometric Hand Grip training in normotensive individuals.[14]

Christopher Del Balso et al studied about the adaptations that occur in skeletal muscle by short-term isometric resistance training. Their results suggested that increases in MVC in the first few days of isometric resistance training can due to an increase in the rate of activation which is seen at the onset of muscle contraction.[15] Donald R Melrose et al studied about the gender differences in Cardiovascular response to isometric exercise in the seated and supine positions. They found that the Diastolic Blood Pressure, Mean Arterial Pressure, Heart Rate were significantly higher in males at first minute of exercise, following thirty seconds of recovery.[16]

Eino Hietanen demonstrated that in mild exercise the heart rate and blood pressure increase much more than during dynamic exercise at the same oxygen uptake level.[17]

CONCLUSION

From the results of this study it can be concluded that the post exercise heart rate, systolic blood pressure, diastolic blood pressure and mean arterial blood pressure were significantly higher than the pre-exercise values. The mean HR, SBP, DBP and MAP were greater for men than women in different postural positions and after exercise. These findings support the results of previous investigators that have shown that upon initiating isometric tension, increases in heart rate, systolic blood pressure, and diastolic blood pressure occur. The sustained handgrip isometric exercise causes a rapid, significant increase in systolic and diastolic blood pressure and imposes an acute load on the left ventricle. This type of stress due to isometric handgrip exercise may be useful in evaluating the hemodynamic reserve of patients with heart disease. To summarize, factors responsible for differences in cardiovascular response due to gender appear to be numerous and further study is essential to elucidate the specific mechanisms.

AUTHOR NOTE

S Srikanth Professor, Physiology,**(Corresponding Author):email**: minni_shp@yahoo.com
Naga Teja D (Med. Physiology)
Dr PSIMS &RF, Chinnavutapalli, Andhra Pradesh, India
Pragathi BH (Med Physiology), Tutor, Physiology, St. Joseph Dental College, Duggirala, Eluru.

REFERENCES

1. Nami R, Martinelli M, Pavese G, Bianchini C, Buracchi P, Gennari C. [Evaluation of the adrenergic and pressor response to the hand-grip test in young athletes]. *Minerva Med*. 1988 Nov;79(11):937-42.
2. Schibye B, Mitchell JH, Payne FC, Saltin B. Blood pressure and heart rate response to static exercise in relation to electromyographic activity and forcedevelopment. *Acta Physiol Scand.* 1981 Sep;113(1):61-6.
3. Tallarida G, Baldoni F, Peruzzi G, Raimondi G, Massaro M, Sangiorgi M.Cardiovascular and respiratory reflexes from muscles during dynamic and staticexercise. *J Appl Physiol Respir Environ Exerc Physiol.* 1981 Apr;50(4):784-91.
4. Chester A Ray, Dario I Carrasco. Isometric handgrip training reduces arterial pressure at rest without changes in sympathetic nerve activity. *Am. J. Physiol. Heart Circ. Physiol.*2000; 279(1): H245- H249.
5. Grucza R, Smorawiński J, Cybulski G, Niewiadomski W, Kahn JF, Kapitaniak B,Monod H. Cardiovascular response to static handgrip in trained and untrained men.*Eur J Appl Physiol Occup Physiol.* 1991;62(5):337-41.
6. Asmussen E. Similarities and dissimilarities between static and dynamicexercise. *Circ Res.* 1981 Jun;48(6 Pt 2):I3-10.
7. Tuttle WW and Horvath SM. Comparison of effects of static and dynamic work onblood pressure and heart rate. *J Appl Physiol.* 1957 Mar;10(2):294-6.
8. Rowell LB. Human Cardiovascular Control. Oxford Univ. Press, New York 1993.
9. Audris Zidermanis. Noninvasive Laboratory Exercise Demonstrating Blood Pressure Response to Isometric or Straining Forms of Exercise. *The Journal of Chiropractic Education.*14 (2): 63–67, 2000.
10. Ehsani AA, Heath G, Hagberg J, Schechtman K. Noninvasive assessment of change in left ventricular function induced by graded isometric exercise in healthy subjects. *Chest.* 1981; 80:51-55.
11. Lind AR, McNicol GW. Circulatory responses to sustained hand-grip contractionsperformed during other exercise, both rhythmic and static. *J Physiol.* 1967Oct;192(3):595-607.
12. Cembada OA Akinwande, Babalola JF , Sayi-Adeyemo, Obejideas. Gender differences in cardiovascular responses to upper extremities isometric exercises in normotensive subjects. *Nigerian Journal of Medical Rehabilitation.* Dec 2007;12, (20) .
13. Stebbins CL, Walser B, Jafarzadeh M. Cardiovascular responses to static and dynamic contraction during comparable workloads in humans. *Am J Physiol RegulIntegr Comp Physiol.* 2002 Sep;283(3):R568-75.
14. McGowan CL, Levy AS, Millar PJ, Guzman JC, Morillo CA, McCartney N, Macdonald MJ. Acute vascular responses to isometric handgrip exercise and effects oftraining in persons medicated for hypertension. *Am J Physiol Heart Circ Physiol.* 2006 Oct;291(4):H1797-802.
15. Del Balso C, Cafarelli E. Adaptations in the activation of human skeletalmuscle induced by short-term isometric resistance training. *J Appl Physiol*(1985). 2007 Jul;103(1):402-11.
16. Melrose D. Gender differences in cardiovascular responses to exercise in the seated and supine positions. *JEPonline.* 2005; 8(4):29-35.
17. Hietanen E. Cardiovascular responses to static exercise. Scand *J Work Environ Health.* 1984 Dec;10(6 Spec No):397-402.