

GENDER DIFFERENCES IN CARDIOVASCULAR RESPONSE TO UPPER EXTREMITIES ISOMETRIC EXERCISES IN NORMOTENSIVE SUBJECTS

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SUMMARY

Background and objective: Studies on gender differences in cardiovascular responses to isometric exercise have been numerous and conflicting. The objective of this study was to determine if the cardiovascular responses to upper extremities isometric exercises differ between apparently healthy male and female subjects.

Methods: One hundred and sixty apparently healthy adults with the mean age of 39.0 ± 11.04 years were consecutively recruited into the study. This consisted of 80 males (39.0 ± 10.82 years) and 80 females (38.96 ± 11.25). Data were obtained on participants' age, height, weight, body mass index, blood pressure, heart rate, and Rate Pressure Product. Data were summarized using descriptive statistics of mean and standard deviation. Independent -test was used to compare physical characteristics between genders while repeated measure of ANOVA was used to compare the pre and post isometric exercises cardiovascular parameters between genders. Level of significance for all tests was set at $p < 0.05$.

Results: The baseline cardiovascular parameters were not significantly different ($p > 0.05$) between the male and the female participants. The post exercise cardiovascular parameters were significantly greater ($p < 0.05$) than the baseline values without gender bias. However, the post exercise SBP and RPP were significantly different ($p < 0.05$) between the male and the female participants respectively.

Conclusion: Isometric exercises of the upper limbs can lead to a significant increase in cardiovascular parameters among apparently healthy male and female subjects. Higher ventricular contraction is evoked among males

leading increased SBP while the myocardial oxygen uptake and the measure of the oxygen consumption of the heart muscles of the female participants in response to upper extremities isometric exercises is higher than that of the males as demonstrated by the RPP.

Key words: Isometric exercises, cardiovascular response, upper extremities exercises.

INTRODUCTION

Isometric exercise has been reported to lead to increases in heart rate, systolic blood pressure, and diastolic blood pressure (Humphreys and Lind, 1963; Lind et al, 1964; Tipton, 1991; Arrol and Beaglehole, 1992; Cable T, 1998; Stendig-Lindberg, 2004). The larger the muscle groups that are involved in isometric tension the greater the consequent cardiovascular responses to it (Mitchell et al, 1980; Seals et al, 1983). In spite of this, isometric exercise remains an important modality in patients' rehabilitation among physical therapists. It has been reported to be effective in preventing a substantial loss of muscle mass and function during the period of recovery from an injury with joint immobilization (Astrand and Rodahl, 1977). Different forms of isometric exercises e.g. functional isometrics have been employed in some advanced training programmes (Jackson *et al* 1985) and also in strength and endurance training (Fox and Matthews 1981).

Cardiovascular response to exercise has been used as major criteria in exercise prescription for both the patients and healthy population (Banner et al, 1989;

Laughlin 1999). Noteworthy attempts abound in explaining the mechanisms responsible for the cardiorespiratory changes to exercise in health and in disease states but they are at best inconclusive and conflicting (Astrand and Rodahl, 1977; Seals et al, 1983; Petrofsky and Phillips, 1986; Mohrman, 1997; Laughlin, 1999; Melrose, 1999). Also, the proposed mechanisms attempting to explain gender differences in cardiovascular responses to isometric exercise have been numerous and conflicting (Melrose, 1999). However, it has been noted that the substantial anatomical, physiological, and morphological differences that exist between men and women may affect their exercise capacity and influence the magnitude of response to exercise (Gatzke, 2005). The objective of this study was to determine if the cardiovascular responses to upper extremities isometric exercises differ between apparently healthy male and female subjects.

MATERIALS AND METHODS

One hundred and sixty (80 males and 80 females) apparently healthy adults whose ages ranged between 20 and 59 years and comprises of clinical students and staffs of the University College Hospital, Ibadan, Nigeria were recruited consecutively into this study. The eligible participants reported no previous history of cardiovascular or neurological condition on interview. On observation the participants were screened to eliminate any disability limiting the ability to exercise with the upper extremities. The informed consent of the participants was obtained before the commencement of the study. Data were obtained on participants' age, height, weight, blood pressure, heart rate and Rate Pressure Product (RPP).

Instrumentation

Metric Scale: Hanson Model, China was used to measure weight to the nearest 0.1 kg Height meter: A meter rule with calibration obtained by attachment of an inelastic tape measurement (Butterfly brand, China) was used to measure height to the nearest 0.1 cm. Sphygmomanometer: An Accousson mercury-in-glass sphygmomanometer (Yamasu model, Japan) was used to measure blood pressure in millimetre mercury (mmHg). Stethoscope: A Littman stethoscope (U.S.A) was used with the Sphygmomanometer to measure the blood pressure. Stop watch: Heuer, Track mate brand stop watch was used to time the duration of exercise and heart rate. Hand held dynamometer: Takei Kiki Kogyo dynamometer was used for modified isometric strength exertion of the upper extremities with the participants in the upstanding position (Fess, 1995; Hamilton et al, 1994; Stephens et al, 1996)

Procedure

The participants were fully informed about the purpose of the study and their consents were obtained. They were interviewed to ensure they met the study's

inclusion criteria. The participants' biodata were taken and recorded. The baseline cardiovascular parameters were taken and recorded. The participants in the upstanding position performed 3 upper extremities isometric exercise for 3 minutes which comprises of two repetitions of pushing against the wall with the outstretched arms for 30 seconds each and they were instructed to exert maximal tension on the wall. Two repetitions of isometric contractions using the hand grip dynamometer, the participants were in the upstanding position with the arms fully extended by the side of the body and they were instructed to exert maximal tension on the hand grip dynamometer and hold it for 30 seconds. Two repetitions of isometric contractions with the hands clasped together and brought to the manubrosternal level of the chest while the shoulders are 60°-70° abducted (winged). The participants were instructed to maximally generate tension by pressing the opposite hands against each other in the exercise position and hold it for 30 seconds. During the exercises the participants were instructed to avoid Valsalva maneuver by not holding their breath and were instructed to do rhythmic breathing in order to minimize the pressor response. On completion of the three isometric exercise bouts, the post exercise cardiovascular parameters were measured. Thereafter, the participants were asked to rest for 10 minutes before discharge.

Computations

The Rate Pressure Products (RPP), which is a useful index of the cardiac stress and is known to be a valid predictor of the myocardial oxygen consumption at rest and during exercise, was evaluated using the formula; $RPP = SBP \times HR$ (Pollock and Wilmore, 1990; Balogun et al, 1990).

Statistical analyses

Data was analyzed using the Statistical Package for Social Sciences [SPSS] version 11.0. (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics of mean and standard deviation were used to summarize the data and Independent t-test was used to compare the participants' physical characteristics by gender. Repeated measures ANOVA and Duncan post hoc test was used to compare the resting and post isometric exercises cardiovascular parameters by gender. Level of significance for all tests was set at $p < 0.05$.

RESULTS

A total of 160 apparently healthy adults participated in this study with the mean age of 39.0 ± 11.04 years. The physical characteristics of the participants by gender are presented in Table 1. The males and females were age matched with no significant differences in their height and weight respectively. However, the BMI of the female participants was significant ($t = -4.360$; $p > 0.001$) greater than that of the males. This indicates that the females had

higher level of adiposity than their male counterparts. Repeated measures ANOVA and Duncan post hoc test comparison of the resting and post isometric exercises cardiovascular parameters by gender is presented in Table 2. There were significant differences between the resting and post isometric cardiovascular parameters (HR, SBP, DBP and RPP) without gender bias. The 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. These results indicate that more blood is pumped by the left ventricle into the aorta in response to upper extremities isometric exercise among males than females; while the myocardial oxygen uptake and the measure of the oxygen consumption of the heart muscles of the female participants in response to upper extremities isometric exercises is higher than that of the males. The level of significance was set at $p < 0.05$.

Table 1: Physical characteristics of the participants by gender.

Variable	Male (n = 80)	Female (n = 80)	t	p-value
	Mean ± S.D	Mean ± S.D		
Age (yrs)	39.0 ± 10.82	38.96 ± 11.25	0.043	0.966
Height (m)	1.66 ± 0.07	1.64 ± 0.06	1.655	0.100
Weight (Kg)	65.3 ± 5.03	66.6 ± 7.95	1.769	0.079
BMI (Kg/m ²)	21.9 ± 6.44	24.7 ± 5.32	-4.360	0.001*

* indicate significant difference (p is significant at 0.05)
 BMI = Body mass index. S.D = Standard deviation

DISCUSSION

This study investigated the gender differences in cardiovascular response to upper extremities isometric exercises among apparently healthy subjects. There was no significant difference in the physical characteristics of the participants by gender. However, the measure of adiposity as indicated by BMI was significantly higher among women than men. The result of this study showed that the post exercises heart rate, systolic blood pressure; diastolic blood pressure and rate pressure product respectively were significantly higher than the pre-exercise values. Therefore, upper extremities isometric exercises had a significant effect on the heart rate, systolic blood pressure, diastolic blood pressure and rate pressure product respectively. These findings supports 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 (Mitchell and Wildenthal, 1974; Mitchell et al, 1981; Seals et al, 1988; Verhaaren et al, 1994; Howden et al, 2006).

The finding of this study revealed no significant gender differences in the cardiovascular parameters of the participants at baseline. However, only SBP demonstrated a significant gender bias in response to upper extremities isometric exercises. Several investigations have measured cardiovascular response to isometric exercise between genders (Sanchez et al, 1980; Ettinger et al, 1996; Jones et al, 1996). The results of these investigations have been reported at best inconsistent (Jones et al, 1996; Melrose, 1999) and do not seem to follow a definite pattern. Sanchez et al (1980) found that sustained isometric contractions showed similar blood pressure responses between genders while Ettinger et al (1996) did show attenuated increases in blood pressure in females.

Table 2: Repeated measures ANOVA and Duncan post hoc test comparison of the resting and post isometric exercises cardiovascular parameters by gender.

Variables	Male		Female		F-ratio	P value
	Pre-Ex X ± S.D	Post-Ex X ± S.D	Pre-Ex X ± S.D	Post-Ex X ± S.D		
HR	75.2±5.13 ^a	79.0±7.74 ^b	74.9±7.08 ^a	79.8±7.43 ^b	1.517	0.036*
SBP	125.8±12.8 ^a	130.6±12.5 ^b	126.7±11.9 ^a	128.7±13.8 ^c	0.048	0.053*
DBP	75.9±7.74 ^a	79.0±7.58 ^b	74.8±7.58 ^a	78.3±7.74 ^b	1.290	0.036*
RPP	9469.9±1108.1 ^a	9699.9±2730.0 ^b	9416.9±1068.03 ^a	9786.81±2940 ^a	33.67	0.042*

* indicate significant difference.
 Superscripts (a,b,c).

For a particular variable, mode means with different superscript are significantly (P < 0.05) different. Mode means with same superscripts are not significantly (P>0.05) different. The pair of cell means that is significant has different superscripts.

Key:
 S.D = Standard deviation
 SBP = Systolic blood pressure
 DBP = Diastolic blood pressure
 RPP = Rate pressure product

The proposed mechanisms attempting to explain gender differences in cardiovascular responses to exercise have been numerous and conflicting (Melrose, 1999). Some studies that found significant gender differences in cardiovascular responses to static exercise believed it was due to differences in sympathetic-parasympathetic or adrenal interactions at the cardiac level (Sanchez et al, 1980; Ettinger et al, 1996). This present study found a significant gender difference in SBP in response to upper extremities isometric exercise with the males having higher mean SBP value. This corroborates an analysis of twelve gender comparison investigations that focused on isometric hand grip exercises and reported that men have greater SBP and catecholamine response to acute stress (Stoney et al, 1987).

The cardiovascular response to exercise has been used as major criteria in exercise prescription for both the patients and healthy population (Laughlin, 1999; Banner et al, 1989; ACSM, 1993; Wenger and Hellerstein, 1984). Defoyd (2000) advised that before beginning an exercise program, patients should be screened for cardiovascular risk factors, as well as signs and symptoms suggestive of cardiopulmonary disease. As the increase in arterial blood pressure secondary to static effort could cause a pressure overload of the heart, which can be dangerous for the persons with cardiovascular diseases (Mitchell et al, 1981; Gruzca, 2007).

CONCLUSION

We conclude that isometric exercises of the upper limbs can lead to a significant increase in cardiovascular parameters of apparently healthy adults without gender bias. The result of this study demonstrated that more blood is pumped by the left ventricle into the aorta in response to upper extremities isometric exercise among males than females as indicated in the higher SBP among males than females. While the myocardial oxygen uptake and the measure of the oxygen consumption of the heart muscles of the female participants in response to upper extremities isometric exercises is higher than that of the males as demonstrated by the RPP. We recommend that assessment of cardiovascular risk factor prior to prescribing isometric exercise be carried out as a routine among physical therapists for healthy and patient populations without gender bias.

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