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Original Research Paper

EFFECT OF GENDER ON ACUTE CARDIOVASCULAR RESPONSES TO ISOMETRIC HANDGRIP EXERCISE

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ABSTRACT

The purpose of this study was to compare the acute cardiovascular responses of healthy young males and females to isometric exercise. In the present study forty healthy normotensive volunteers were recruited and divided into two groups. Subjects in group I and group II included males and females in age group of 20-40 yrs respectively. All the subjects performed IHG exercise. Their HR, BP and QT interval were recorded prior to exercise and after one minute of 40% maximum voluntary contraction of the forearm. Measured QT interval was then corrected for heart rate using Bazett's formula. All the recordings were compared within groups and between groups before and after exercise. Results were analyzed using software STATA 10.At rest we found consistently higher level of SBP (0.000) in males whereas females had higher resting HR (0.003) and prolonged QT interval (0.026). We found no significant difference in DBP. Isometric handgrip exercise induced a higher increase in BP (0.001) in males & greater HR (0.004) response in females which could be because of variation in resting values. Along with these findings QTc interval which is seen to shorten with resistance exercise, showed greater shortening in the females. Our study indicates that the pressor response is well regulated in both sexes. Since cardiovascular response to exercise is major criterion in exercise prescription, resistance exercise can be added as a part of regular physical activity program having lot of favorable effects. These positive effects are seen in both sexes with added advantage for the females, clearing some of the misconceptions about women and resistance exercise.

Keywords: BP-Blood Pressure, SBP-Systolic Blood Pressure, DBP-Diastolic Blood Pressure, ECG - Electrocardiograph, IHG-Isometric Handgrip, HGD-Handgrip Dynamometer, HR-Heart Rate.

INTRODUCTION

Many positive physiological adaptations occur as a result of resistance exercise. Physical changes, such as muscle hypertrophy, decreased adiposity, and enhanced muscular strength, have been reported in several studies. These adaptations have the cumulative effect of increasing quality of life. Static or resistance exercise involves contraction of skeletal muscle without a change in muscle length, hence also known as isometric exercise (iso=same, meter=length). Static exercise produces a cardiovascular response that differs significantly from that observed during dynamic exercise. There are (at least) two neural systems at work when muscles are exercised. The first is central command located in higher centers in the brain. It monitors the nerve signals sent to the muscles and responds by stimulating areas in the brainstem responsible for HR and strength of contraction. The second is feedback systems that detects work in the muscle by monitoring contraction and build up of cellular metabolites. It then signals the brainstem to increase CO to compensate for increased muscular activity.[1, 2] During resistance exercise, a number of physiological changes occur in the heart rate, blood pressure, metabolic rate, hormone secretion, nerve conductivity, muscle activity, and respiration. These distinctive acute responses are influenced by numerous factors, including active muscle mass, relative intensity of the exercise, number of repetitions, type of exercise (isometric, isotonic, or isokinetic), duration of exercise, use of rest periods between exercises, and the intermittent nature of the exercise performance. Cardiac output increases during static contractions owing to an increase in heart rate, with the magnitude of the increase dependent upon the intensity of exercise. Stroke volume remains relatively constant during low-intensity contractions and decreases during high-intensity contractions. The magnitude and the rate of the increase in heart rate depend on the intensity of contraction. Static exercise is characterized by a disproportionate rise in SBP, DBP and mean BP. Thus a significant pressure load is imposed on the heart, presumably to increase perfusion to active muscles.[3] Along with changes in the cardiac output, HR and BP, resistance exercise also affects the rate corrected QT interval (QT_c) which reflects ventricular repolarization of heart. Slower cardiac repolarization which manifests as longer QT_c interval on ECG indicates the risk of arrhythmias.[4] Although a large number of studies have been conducted using isometric exercise, there is limited research on acute cardiovascular responses to isometric exercise in healthy subjects. The proposed mechanisms attempting to explain sex differences in cardiovascular responses to isometric exercise have been numerous and conflicting.[5,6] More research is necessary to clearly understand the acute cardiovascular responses to isometric exercise in subjects of different sex and the benefits of these effects. In our study we set to confirm the acute cardiovascular responses to isometric exercise in the subjects and whether physical activity in form of resistance exercise is positively associated with responses in both the sexes.

MATERIALS AND METHODS

The present Study was conducted on 40 healthy volunteers (20 males and 20 females) with age of subjects varying from 20-40 years. BP, HR and QT interval was measured in all the subjects before and within one minute of completion of IHG exercise. Blood pressure was recorded with standard mercury sphygmomanometer[7-9] measurement of HR and QT interval was done using lead II of Cardiofax Electrocardiograph (ECG) machine (Medicaid systems). Measured QT interval was then corrected for heart rate using Bazett's formula.

SELECTION OF SUBJECTS

The subjects were recruited for study purely on voluntary basis from Dayanand Medical College and Hospital, Ludhiana. Each of the subjects was briefed about the study and was asked whether they would participate. Those who agreed signed a written informed consent and their detailed medical and related history along with general examination was undertaken. Those subjects who fulfilled the inclusion criteria were enrolled for the study.

Inclusion Criteria

- Age group between 20-40 years of either sex.
- Heart rate (60—100 beats/min)
- Blood pressure (≤ 120/80 mm of Hg)
- Females having regular menstrual history.

The subjects were screened for inclusion into the study. Two measurements of HR and BP were taken per week for two weeks. The average of four readings was taken as the resting parameters. The subjects who did not meet the above requirements or had any history of the following were excluded.

Exclusion Criteria

- Hypertensive
- Diabetic
- Smokers
- Alcoholic
- Subjects who had participated in any isometric training within one month from the onset of study.
- Any history of neuropathy, arrhythmias, prolonged QT interval.
- Females on hormonal therapy.

After all the requirements were fulfilled, forty subjects were shortlisted and divided into two groups of twenty each.

GROUP I : included males in the age group 20-40 years.

GROUP II : included females in the age group 20-40 years.

BP was measured in non dominant arm in seated position after at least ten minutes of rest, before the start of exercise and within one minute of exercise completion. Subjects were labelled as normotensive, if their resting SBP was ≤120 mm Hg and resting DBP was ≤80 mm Hg.[10] SBP was taken as korotkoff phase I (appearance of sound) and DBP was taken as korotkoff phase V (disappearance of sound). HR was calculated from RR interval by continuous recording of lead II on ECG machine (Cardiofax Medicaid Ambala). Speed of ECG paper was 25mm/sec. Heart rate was calculated as follows:

Heart rate = (60× 25) /RR = 1500/ RR (bpm)

Measurement of QT interval was done using lead II. Measured QT interval was corrected for heart rate using the formula :

$QT_C = QT/(RR)^{1/2}$.(Bazett *et al.*[11])

Subjects were explained about the use of the handgrip dynamometer (HGD) prior to beginning of isometric exercise. They were also trained to maintain an effort that would enable them to hold a steady tracking on the pointer of the dynamometer at 40% of their maximum voluntary contraction (MVC). MVC was calculated for each subject. To determine the maximum force (MVC) that the subject can exert with their dominant hand, the subject was asked to exert a maximal effort for less than 2 seconds on HGD. After three minutes rest, another effort was made. After three maximal effort recordings, the greater of three was taken as MVC.[12] After measuring resting HR , BP and QT_C interval the subjects were asked to exert force on the HGD approximately 40% of their MVC (maximum voluntary contraction) with dominant hand and sustain it for a minimum period of 2 minutes till fatigue (not more than 4 minutes if fatigue does not sets in). BP, HR and QT_C interval were measured after completion of IHG exercise. The results were compared within and between groups for changes in HR, BP and QT_C interval in response to IHG exercise.

STATISTICAL ANALYSIS

Data collected on various variables was analyzed statistically. Mean and standard deviation (SD) was computed. Unpaired 't' test was applied to compare the means in different groups and paired 't' test to compare the differences between the means within groups before and after exercise. Data was analyzed using Stata 10 (general purpose statistical software package) software.

RESULTS

In the present study, the acute effects of IHG exercise on HR, BP and QT_C interval in normotensive healthy volunteers have been studied. With exercise both groups show significant increase in SBP, DBP and HR. Whereas QTc interval showed insignificant rise in males and shortening in females. Comparison between the groups show that the resting SBP was found to be significantly (p=0.000) higher in males of younger age group as compared to females of same age group (Table 3). With isometric exercise there was rise in SBP in both groups, (Table 4) with males showing significantly higher SBP values (p=0.004) as compared to females. Resting DBP (p=0.490) was comparable in subjects of younger age group. After exercise DBP increased in males and females of younger age group, with slightly higher increase in males but the comparison was insignificant statistically (p=0.650). Table 3 shows HR response comparison between subjects of younger sex, with females having significantly higher resting HR (p=0.003). As shown in Table 4, there was increase in HR after exercise in subjects of both groups, but females had greater response (p=0.001). In the present study, females in younger age group were found to have significantly prolonged resting QT_c interval (p=0.026) as compared to males of same age group (Table 3, Figure 3b). After performing IHG exercise, QT_c interval showed insignificant shortening in young females as compared to males of same age group(p=0.985, Figure 4b). Hence in present study we found similar BP and HR response in age matched males and females. But, there was shortening of QT_c interval in females with little effect in males.

DISCUSSION

Regular physical activity and high fitness level are associated with reduced risk of premature death from any cause and from cardiovascular disease in particular among asymptomatic men and women, with the benefits extending to even patients with established cardiovascular disease.[13] Earlier exercise programs emphasized on dynamic exercise, but research increasingly suggests that static exercise when appropriately prescribed has favorable effects not only on muscular strength and endurance but also on cardiovascular function, metabolism, coronary risk factors, psychosocial well being and bone mineral density especially important in elderly for maintaining functional independence .[14] In the present study, the acute effects of IHG exercise on HR, BP and QT_C interval in normotensive healthy volunteers have been studied. Forty healthy normotensive volunteers were recruited and divided into two groups. Subjects in group I and group II included males in age group of 20-40 yrs and females in age group of 20-40 yrs respectively. All the subjects performed IHG exercise. Their HR, BP and QT_C interval were recorded prior to exercise and within one minute of cessation of exercise. All the recordings were compared within groups and between groups before and after exercise.

Gender and Blood Pressure Response

In the present study, the resting SBP was found to be significantly (p=0.000) higher in males of younger age group as compared to females of same age group (Table 3). The gender differences in SBP are due to differences in sympathetic and parasympathetic or adrenal interactions at cardiac level.[6] There is preponderance of sympathetic mediated responses in males and of parasympathetic in females.[15] With isometric exercise there was rise in SBP in both groups, (Table 4) with males showing significantly higher SBP values (p=0.004) as compared to females. The higher SBP in males could be due to release of significantly higher levels of epinephrine and nor epinephrine in response to isometric stress known as catecholamine response. Resting DBP (p=0.490) was comparable in subjects of younger age group. After exercise DBP increased in males and females of younger age group, with slightly higher increase in males but the comparison was insignificant statistically (p=0.650). The proposed mechanisms attempting to explain gender differences in cardiovascular responses to isometric exercise have been numerous and conflicting (Melrose, 1999).[6] However, it has been noted that the substantial anatomical, physiological, and morphological differences that exist between males and females may affect their exercise capacity and influence the magnitude of response to exercise.[16, 17] Jones *et al.* and Sanchez *et al.* found that BP responses to various forms of laboratory stressors (IHG) are not consistently influenced by gender.[18,19] Ettinger *et al.* did show greater increase of BP in males as compared to females as in our study.[20]

Gender and Heart Rate Response

Table 3 shows HR response comparison between subjects of younger sex, with females having significantly higher resting HR (p=0.003). As shown in Table 4, there was increase in HR after exercise in subjects of both groups, but females had greater response (p=0.001). This could be because of higher resting levels in females. While the mechanisms underlying sex differences are poorly understood, there are significant differences in cardiovascular system between males and females. The size of heart and major blood vessels are smaller in females than those of age matched males, thus females have approximately 10% lower stroke volume. This explains greater HR response in females which is required to maintain same cardiac output as that of age matched males.[15]

Gender and QT_c interval response

In the present study, females in younger age group were found to have significantly prolonged resting QT_c interval (p=0.026) as compared to males of same age group (Table 3, Figure 3a). Bazett noted that women had slightly, but significantly, longer QT intervals than men, despite having higher resting heart rates (Bazett, 1920).[11] Many studies have since confirmed Bazett's observations of gender-related differences in the ECG.[21-25]

Although the exact mechanism of prolonged QT_c interval in females remains unclear, yet it could be explained by influence of sex hormones, sex related differences in ion channels, conduction velocity and cell to cell coupling.[26] Some studies quoted an influence of ovarian steroids, particularly estrogen, on autonomic regulation of the HR and cyclical changes seen in QT_c interval during different phases of menstrual cycle.[27-31] The effects of estradiol result in suppression of human ether-a-go-go-related gene (hERG) underlying the rapid delayed rectifier current (IKr) by directly binding to the channel, altering channel kinetics by increasing channel rate closure and reducing repolarizing current. Also in the presence of E2 (estrogen receptor), hERG is more sensitive to blockade by drugs. Thus estrogens lead to prolonged QT interval, and increased risk of arrhythmias.[32]

On the other hand, Burke *et al.* found that following autonomic blockade, the QT_c interval was significantly shorter during the luteal phase of the menstrual cycle, suggesting a possible role for progesterone in ventricular repolarization.[33,34] Progesterone modulates the IKs (slow delayed rectifier potassium channels) through non-genomic activation of endothelial nitric oxide synthase (eNOS), reducing the QT interval and hence, susceptibility to Long QT-linked arrhythmias.[22] A number of studies report no change in the resting HR per se at different times of the menstrual cycle in women.[28,35] The sex differences in QT interval are not present in young children but become apparent from the time of puberty.[36,38] In a study, Rautaharju *et al.* suggested that the sex difference in QT_c interval arises as a result of QT shortening in boys at the time of puberty.[36] The QT interval then remains shorter in males than in females until around the age of 50, supporting a major role of androgens in the sex differences in ventricular repolarization. Testosterone brings its effects by modifying cardiac ion channels comprising IKs and L type calcium channels (ICa,L) via eNOS production of nitric oxide (NO),thus hastening repolarization and protecting from drug-induced arrhythmias.[36,24,32,37] In addition to sex-related differences in the QT_c interval, differences in the rate dependence of the QT interval and shape of the T wave have been reported, providing further evidence of gender differences in ventricular repolarization in the human. Females have a steeper QT: RR relation than males, such that the sex differences in QT interval are more apparent at slower heart rates.[25,39,40] The differences in QT interval between adult males and females were maintained following autonomic blockade, suggesting an intrinsic sex-related difference in the processes underlying ventricular repolarization.[33]

After performing IHG exercise, QT_c interval(figure 4b) showed insignificant shortening in young females as compared to males of same age group(p=0.985). There is no clear explanation for the different effect of resistance exercise on ventricular repolarization in males and females. The shortening of QTc interval in females might be due to a greater effect of vagal withdrawal as females have predominantly parasympathetic mediated responses. The sex steroid hormones may also have played a role in the differential effects of exercise on ventricular repolarization in males and females. Similar results were observed by Simonetta Genovesi *et al.*[41] Furthermore, the QT interval evaluation during exercise is subject to several methodological problems: noise and baseline drift which can make it difficult to locate the end of the T wave, and fusion of the end of the T wave with the subsequent P wave can cause problems at elevated heart rates. Rate correction imprecision (particularly at high exercise intensities) has also impeded our understanding of the autonomic effects of exercise and recovery on the QT interval.

Hence in present study we found similar BP and HR response in age matched males and females. There was shortening of QT_c interval in females with little effect in males. This favourably altered the arrythmogenic risk in females, as they are more prone because of prolonged resting QT_c interval as compared to age matched males. Thus along with other benefits resistance exercise as a part of routine physical activity in females has added advantage. Although the resistance exercise is considered safe in healthy people, proper preliminary screening, appropriate prescriptive guidelines and careful supervision is required for those with mild to moderate cardiovascular dysfunction.

SUMMARY AND CONCLUSIONS

In the present study the effect of sex on cardiovascular response to isometric handgrip exercise was studied. On the basis of gender, in present study rise in SBP as well as DBP was seen in young males and females, with males showing statistically significant higher SBP values after exercise as compared to females. There was increase in HR in both males and females of younger age, but females had greater response. QT_c interval shortening was found to be insignificant in age-matched males and females, with females showing greater shortening as compared to males. Since females are more prone to arrhythmias because of prolonged resting QT_c interval as compared to age matched males. This effect favorably reduces the risk of arrhythmias in females.

Since cardiovascular response to exercise is major criterion in exercise prescription, resistance exercise can be added as a part of regular physical activity program. This can help to decrease the risk of chronic diseases and improve the quality of life.

Table 1: Comparison of parameters in male subjects 20-40 years before and after exercise

Parameters	Before Exercise	After Exercise	Paired	p-value
	Mean±SD	Mean±SD	t-value	
SBP(mm/Hg)	112.70±5.810	119.90±8.710	3.170	0.005
DBP(mm/Hg)	78.40±7.440	81.50±10.390	2.290	0.033
HR(beats/min)	75.00±10.400	83.70±9.840	6.450	0.000
QT(secs)	0.370±0.054	0.365±0.427	0.745	0.674
RR(secs)	0.800±0.161	0.716±0.122	3.170	0.005
QTc(secs)	0.409±0.043	0.430±0.042	1.560	0.135

Table 2: Comparison of parameters in female subjects 20-40 years before and after exercise

Parameters	Before Exercise	After Exercise	Paired	p-value
	Mean±SD	Mean±SD	t-value	
SBP(mm/Hg)	104.50±6.540	111.30±8.970	4.070	0.001
DBP(mm/Hg)	76.50±9.640	80.10±8.910	3.260	0.004
HR(beats/min)	85.45±10.590	94.15±13.050	4.200	0.001
QT(secs)	0.375±0.043	0.350±0.046	1.620	0.120
RR(secs)	0.702±0.088	0.637±0.074	4.140	0.001
QTc(secs)	0.439±0.036	0.429±0.041	0.972	0.343

Table 3: Comparison of parameters in males and females of 20-40 years age before exercise

Parameters	Males 20-40 years	Females 20-40 years	Unpaired	p-value
	Mean±SD	Mean±SD	t-value	
SBP(mm/Hg)	119.90±8.710	104.50±6.540	4.180	0.000
DBP(mm/Hg)	81.50±10.390	76.50±9.640	0.698	0.490
HR(beats/min)	83.70±9.840	85.45±10.590	3.160	0.003
QTc(secs)	0.430±0.042	0.439±0.036	2.320	0.026

Table 4: Comparison of parameters in males and females of 20-40 years age after exercise

Parameters	Males 20-40 years	Females 20-40 years	Unpaired	p-value
	Mean±SD	Mean±SD	t-value	
SBP(mm/Hg)	119.90±8.710	111.30±8.970	3.070	0.004
DBP(mm/Hg)	81.50±10.390	80.10±8.910	0.460	0.650
HR(beats/min)	83.70±9.840	94.15±13.050	3.430	0.001
QTc(secs)	0.430±0.042	0.429±0.041	0.019	0.985

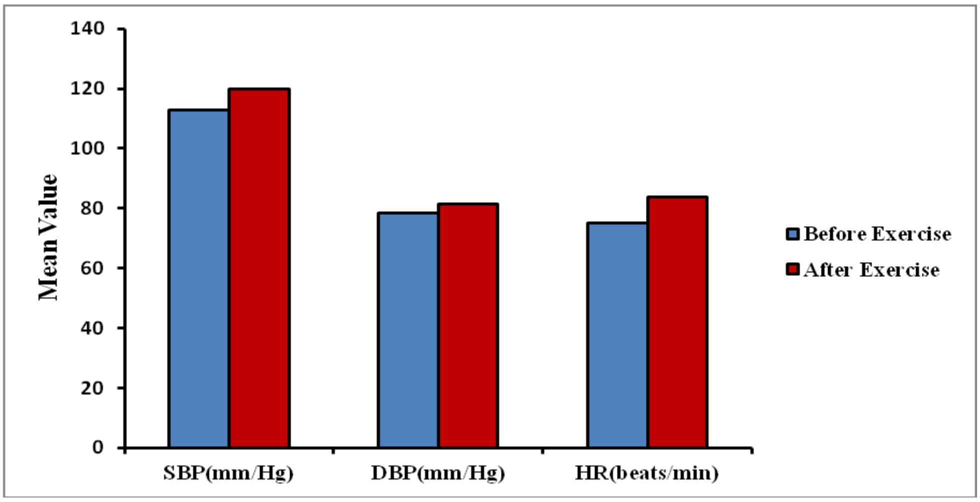

Figure1a: Showing comparison of parameters in male subjects 20-40 years before and after exercise

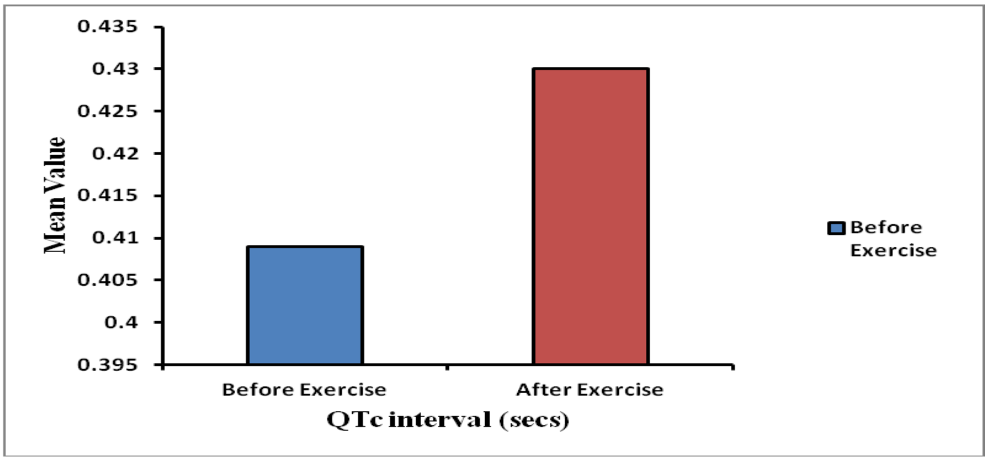

Figure1b: Showing comparison of QTc interval in male subjects 20-40 years before and after exercise

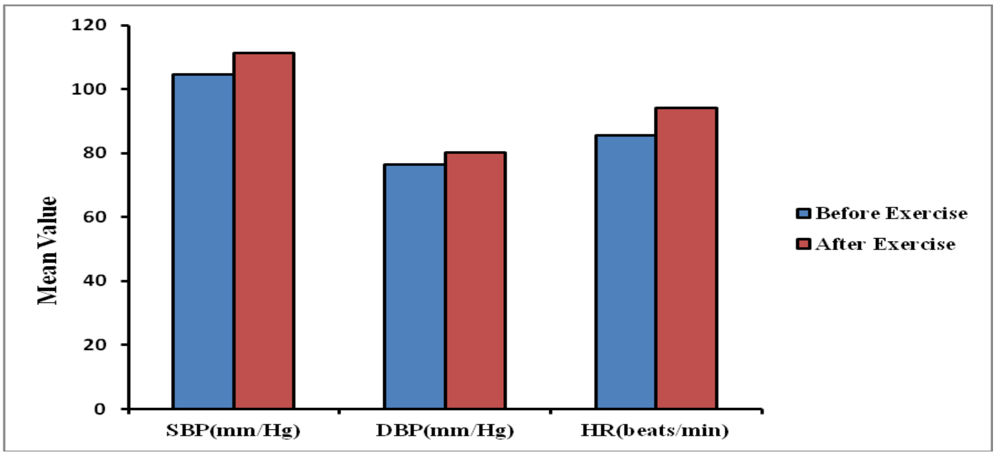

Figure 2a: Showing comparison of parameters in female subjects 20-40 years before and after exercise

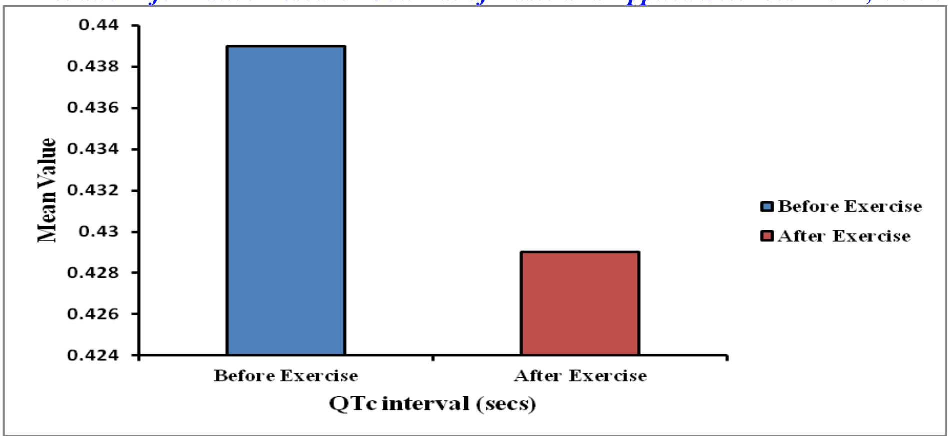

Figure 2b: Showing comparison of QTc interval in female subjects 20-40 years before and after exercise

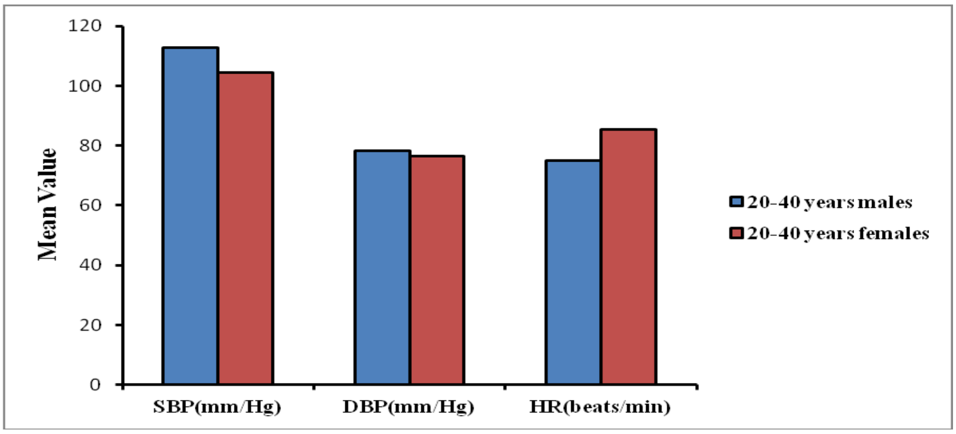

Figure 3a: Showing comparison of parameters in male & female subjects before exercise

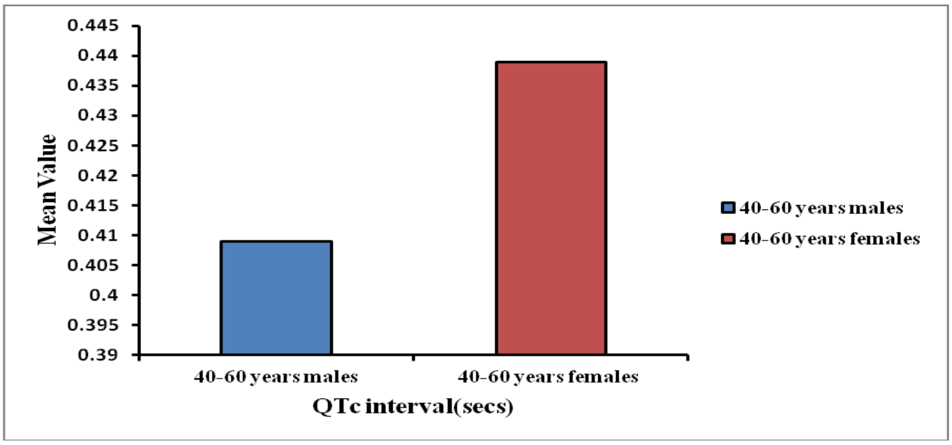

Figure 3b: Showing comparison of QTc interval in male & female subjects before exercise

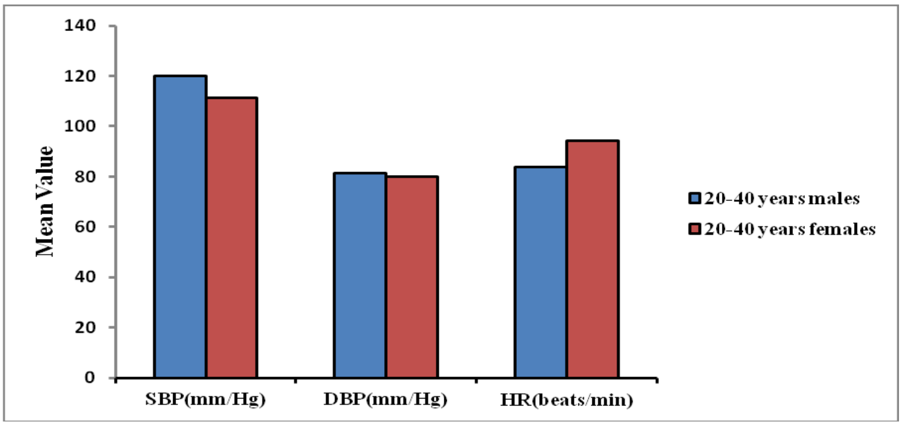

Figure 4a: Showing comparison of parameters in male & female subjects after exercise

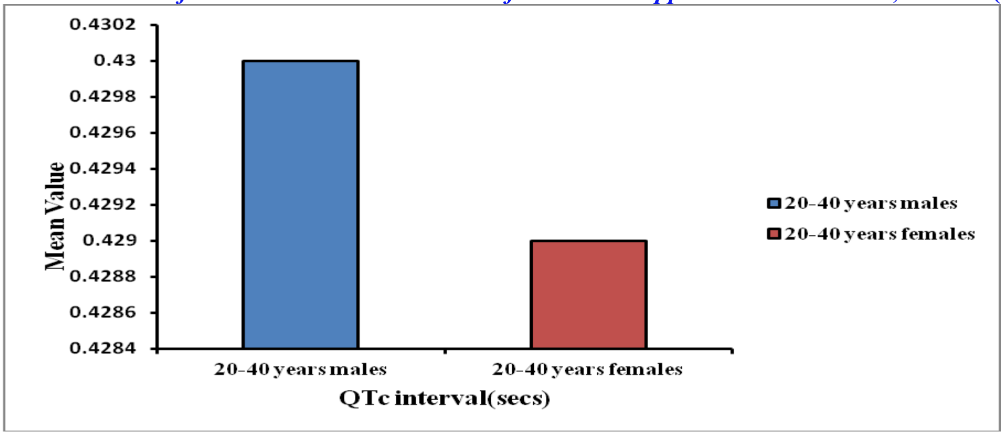

Figure 4b: Showing comparison of QTc interval in male & female subjects after exercise

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