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ABSTRACT

Gender influences blood pressure (BP) and heart rate variability (HRV). The purpose of this study was to investigate the influence of gender on BP and HRV during increasing intensities of isometric hand grip (IHG) exercise. Nineteen (n=19) (10 males, 9 females) participants aged 25.7±0.9 and 27.0±0.6 years (Mean± SEM), with height and weight of 173.4±3.1 cm, 72.8±3.7kg and 160.9±1.6 cm, 59.3±3.4 kg volunteered after ethical approval. BP, HRV and maximum voluntary contraction (MVC) was measured at rest. Thereafter, participants underwent 30% MVC for 2 minutes during which BP and HRV was taken with 10 minutes rest. Contractions were amplified to 35, 40, 45% MVC. One-Way ANOVA compared Mean±SEM values at 95% significance. The systolic blood pressure (SBP) increased significantly in females (p<0.001) than males (p<0.01); diastolic blood pressure (DBP) increased significantly in both gender (p<0.001); average number of heart beats increased significantly in males (p<0.001) than females (p<0.01); significant increase in LF/HF ratio in females (p<0.01) but not in males. However, there was no significant difference in the standard deviation of N-N interval (SDNN), low frequency (LF), high frequency (HF), very low frequency (VLF), root mean square of standard deviation (RMSSD), total frequency power (TFP), proportion of numbers of pairs of successive intervals (Pnn50) in both genders. This study may suggest a higher sympathetic influence (following rise in SBP and LF/HF ratio) in females than males during IHG exercise. Thus, variations exist in BP and HRV during short interval, altered intensities IHG exercise in both genders.

Keywords: *Gender, heart rate variability, blood pressure, isometric handgrip exercise*

INTRODUCTION

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The impact of sexual dimorphism on physiological responses to exercise has been a major issue. Gender variation in exercise responses is a major indicator in understanding gender-specific adaptations to exercise for athletic performance and overall wellbeing (Dimpka and Ugwu, 2009; Gleim *et al*., 1991; Ogawa *et al*., 1992). Exercise is a planned, repetitive, and purposeful activity used to enhance physical fitness, health, and wellbeing (Fletcher *et al.,* 2001). Hand grip exercise is a simple form of isometric exercise which involves exerting a sustained force by muscles of the forearm and hand to the arm with or without the use of a hand grip transducer (Clerke *et al., 2005)*. During isometric hand grip (IHG) exercise, the systolic blood pressure (SBP) increases significantly due to increase in systolic contractile force (stroke volume) while the diastolic blood pressure remains unchanged or exhibit slight change due to reduction in peripheral vascular resistance to increase blood supply to exercising muscles (O'Sullivan and Bell., 2000; Surawics *et al.,* 2001). The elevated SBP with or without the DBP is proportional to the exerted efforts and intensity of exercise (Fielding, 2006), and an exaggerated increase in SBP predicts development of future hypertension which is an independent predictor of mortality (Manolio *et al., 1994*). It has been shown that exercise training may result in sustained reduction in resting blood pressure in hypertensive individuals (Tipton et al. 1991), while acute bouts of exercise may elicit a transient reduction in blood pressure (e.g. Floras and Senn 1991). The above study outcomes may suggest that both endurance and resistance exercise may act as a useful, non-pharmacological aid in the treatment of hypertension. However, majority of investigations have documented endurance (Pescatello et al. 1991; Floras and Wesche 1992) and or resistance (Brown *et al*., 1994) exercise as the stimuli for post-exercise hypotension.

At the onset of exercise, the heart rate and blood pressure increase abruptly following increase in sympathetic nervous system action and the dramatic action of catecholamines (Davis *et al., 2000*). This initial increase is being facilitated by the resetting of the arterial baroreflex (by the baroreceptors) to a higher pressure. At this instance, the effect of the arterial baroreflex predominates the arterial pressure, which elicits a blood pressure error (DiCarlo and Bishop, 2001). This error is rectified by stimulating SNA and inhibiting parasympathetic nerve system activity (PNA), which increases the cardiac output and peripheral resistance and, also the arterial blood pressure. At the end of the exercise, there is concomitant loss of the central command and the resetting of the arterial baroreflex to a lower pressure resulting in inhibition SNA, reduction in catecholamine release, and reduction in peripheral resistance and arterial pressure (Ettinger *et al., 1996;* Jessica *et al., 2006*). Hence, the central resetting of the arterial baroreflex has a physiological role in controlling sympathetic action and arterial pressure.

Gender disparity in the autonomic nervous system may be attributable to developmental differences or consequence of levels of male and/or female hormones (Scott *et al., 2007)*. There are reliable facts which suggest that males have higher sympathetic and females have higher parasympathetic cardiac autonomic activity (Dart *et al., 2002*). Men has been shown to have higher level of circulating catecholamines and enhanced cardiovascular responses to exercise (Carter *et al.,* 2003; Davis *et al.,* 2000) than women. Non-invasive measures of the autonomic neural control of the heart using the HRV specified that women may have a higher parasympathetic and less sympathetic control of the heart than men (Carter *et al.,* 2003; Dimpka and Ugwu, 2009; O'Toole, 1989). With higher levels of cathecholamines generated during exercise, men may experience higher cathecholamine-induced reductions in responsiveness and greater reduction in left ventricular function especially following prolonged strenuous exercise (Gandevia and Hobbs, 1990; Jessica *et al.,* 2006). The cardiovascular responses to IHG exercise have been reported to be less in premenopausal women than postmenopausal women and men (Ettinger *et al.*, 1995; Stephen *et al.*, 2000). This disparity has been attributed to oestrogen, a steroidal hormone that is well known to reduce the vascular resistance and whose receptors are located on the cardiac myocytes and fibroblasts. A higher circulating level of oestrogen is seen in women (195-361 pmol/L) than men (134±70 pmol/L) (Stephen *et al*., 2000). The cardiovascular parameters taken during exercise from previous studies showed an increase in autonomic nervous influence, cardiovascular and counter regulatory responses to exercise in men than women (Ettinger *et al.*, 1995; Stephen *et al*., 2000).

Heart rate variability (HRV) is a physiological occurrence which reflects a balance between the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS) autonomic function. A wide variation is seen when the PNS influence outweighs the SNS (Winsley *et al.*, 2003) and vice versa. The high frequency (HF) band is a frequency domain that is primarily parasympathetically mediated while the low frequency (LF) band is both parasympathetically and sympathetically mediated (Thayer *et al.,* 2012). Several factors have been shown to affect HRV; age (Catai *et al.,* 2002); gender (Carter *et al.*, 2003; Stephen *et al.,* 2000); pathological states e.g myocardial infarction and heart failure which accounts for autonomic imbalances (Ucar *et al.*, 2010); diabetes neuropathy (Akinci *et al.*, 1993); respiration (decreases with expiration and increases with inspiration); stress (Thayer *et al.*, 2010). Other factors include smoking (Fifer *et al.,* 2009), alcohol, drugs, caffeinated products (Koenig *et al.,* 2013) and postures.

Previous studies documented increase in heart rate and blood pressure during IHG exercise (Davis *et al.*, 2000; Surawics *et al.*, 2001; George *et al.*, 2012; Fletcher *et al.*, 2001) in both genders, but with the males having a higher resting blood pressure and heart rate (Dart *et al.,* 2001, Thompson *et al.,* 2011) and exaggerated cardiovascular response during the exercise (Carter *et al.*, 2003; Stephen *et al.,* 2000; Ettinger *et al.*, 1995) than females (Harpreet and Majinder, 2011). The effect of IHG exercise on heart rate variability has not been studied widely, the few studies are contentious (Cassandra *et al.*, 2012; Takashi *et al.,* 2011; Mantaras *et al.,* 2005; Kiviniemmi *et al.,* 2007). However, there is paucity of research on the consequence of increasing intensities of IHG exercise on heart rate variability and blood pressure with or without gender influences and disparities.

Therefore, the aim of this study is to investigate, identify and quantify blood pressure and heart rate variability changes that may occur during increasing intensities of IHG exercise in untrained healthy subjects; and to further evaluate gender disparities that may exist. The findings in this study may suggest exercise recovery regimens for trained and untrained male and female healthy individuals.

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MATERIALS AND METHODS

Ethical approval of this research was obtained from the School of Health, Sports and Bioscience ethics committee, University of East London, Stratford Campus, United Kingdom. All experiments were conducted in the physiology laboratory, Room 201 of the clinical education building at Stratford Campus of the University of East London. This study lasted for four weeks.

Participants

Nineteen healthy subjects (n=19; male=10, female=9) aged 25.7 years ± SEM 2.5, and 27.0 years ±SEM 0.6 respectively agreed to participate in this study. Participants recruited were postgraduate students at the University of East London. The mean height ± SEM, weight ± SEM in both males and females were 173.4 cm ± 17.1, 72.8 kg ± 7.2 and 160.8 cm ± 1.6, 59.3 kg ± 3.4 respectively. Preliminary questionnaires such as the PARQ (Physical Activity Readiness Questionnaire), Personal Health Questionnaires were filled by the participants to eliminate respiratory or cardiovascular disorders. Participants with medical history of respiratory or cardiovascular diseases were excluded from the study. Written consent was obtained from all participants, and they were allowed to ask any question about the study at any time and allowed to leave the study without giving any reason as stated on the information sheets.

Equipment

Equipment used were stadiometer for height measurement, Seca weighing balance for weight measurement, hand grip transducer (MIE) for performing isometric hand grip exercise, heart rate monitors (polar watch and chest belt) for measuring heart rates and variables, Omron automated blood pressure monitor (M7i) for measuring blood pressures and stop clock for timing the experiment.

Protocol

Before the day of experiment, participants were taken to the experimental room, protocol was explained, and they were allowed to familiarise with the procedures and the use of equipment. They abstained from food for 2 hours before the experiment, avoided caffeine or caffeine containing products, alcohol, and heavy exercise 48 hours before the experiment. All participants filled the Pre-test health questionnaire (to record personal health details and behaviours); PARQ, Information sheets and Consent forms. On the day of experiment, room was prepared (quiet, neat, and temperature controlled). Equipment was checked, assembled, and calibrated appropriately. Start time of the experiment and room temperature was noted. Weight, height was measured with the use of a stadiometer and a weighing balance without shoes on and with light clothes on. Participants rested for 10 minutes while in sitting position during which blood pressure, heart rate variability (HRV) were measured. This was taken as the control reading. The frequency domain and time domain of the HRV was transferred from the polar watch to the computer through a USB flash and a polar infra-red connection cable (RS-232). The USB flash was connected to the computer, and the polar watch was set to connect the mode to transfer the data to the computer. Participants exerted a maximal grip on the hand grip transducer below the red line, this is assumed

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to be the maximal voluntary contraction (MVC). A rest period of 10 minutes was ensured before they proceeded with the exercise. The MIE software measures the maximum strength and calculates 30% of the MVC. Participants were told to hold the hand grip and exert force on the handle to maintain the target range of 30% MVC for 2 minutes, during which blood pressures, heart rate, and heart rate variability were taken. This was followed by a rest period of 10 minutes. Strength was increased to 35%, 40%, and 45% MVC respectively for 2 minutes during which BP, HR, and HRV was taken followed by a 10-minute rest period at each exercise phase. Readings were taken 5 minutes into recovery. All data collected before, during, and after exercise were saved for further analysis.

Data Analysis

Heart rate variability: The HRV analysis polar precision performance software 4 on the computer was used to analyse all saved HRV data. The computer labelled each QRS complex additionally artifices were removed and saved manually by moderate error correction option on the software. Each edited file of 2 minutes HRV data was analysed and the analysed HRV components (time domain and frequency domain variables) were exported to Microsoft excel. The frequency domain and time domain were determined in our study: High frequency (HF), Low frequency (LF), Low frequency/ High frequency ratio (LF/HF), Very low frequency (VLF), Standard deviation of NN intervals (SDNN), Root mean square of standard deviation (RMSSD), Proportion of NN50 divided by total number of NN intervals (Pnn50), and the Total Frequency Power (TFP).

Blood Pressure: The systolic and diastolic blood pressures were taken using the Omron automated monitor. Two readings of blood pressure were taken at each stage of the experiment with the average blood pressure recorded.

Statistical Analysis

Descriptive statistics (Mean, N, SD, SEM) were calculated using excel software, and were plotted by graph pad prism 5 software. The number of subjects (N), mean (M), standard error mean (SEM) was plotted against control and different exercise conditions (30% MVC, 35 %MVC, 40% MVC, and 45% MVC) in males and females. One way ANOVA was used to find the differences in mean at different exercise conditions in both genders, this was followed by nonparametric post-test (bonferroni) and significance set at 95% ($p< 0.05$).

RESULTS

Blood pressures (systolic, diastolic), heart rate variables (average no of heart beats, SDNN, HF, LF, LF/HF, VLF, RMSSD) were plotted against exercise conditions (30%, 35%, 40%, 45% MVC) in both genders.

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Blood pressure

As shown in Figure 1/ Table 1, as exercise intensities increased, isometric hand grip exercise significantly increased the mean systolic blood pressure (MSBP) from baseline value of 118.0±3.3 to 134.4±4.2 (mmHg) in males and from baseline value of 99.5±3.4 to 130±8.7 (mmHg) in females (overall p value of the repeated measures ANOVA in male as 0.0020 and < 0.001 in females). In Figure 2 and Table 1, mean diastolic blood pressure (MDBP) in male subjects significantly increased from 73.6±0.0 to 88.2±4.0 (mmHg) while that of female subjects significantly increased from 69.7±0.0 to 99.2±6.2 (mmHg) (overall p value in males is 0.0001 and in females is <0.0001).

Heart rate variability

Average number of heart beats significantly increased from baseline values of 82.7±3.0 to 91.0±2.1 (mmHg) in males and 84.7±2.4 to 98.4±3.4 9 (mmHg) in females. The resting value of the average number of heart beats in males was higher than in females. Overall P value in males is 0.0005 and 0.012 in females.

Standard Deviation of R-R interval (SDNN)

In all isometric hand grip exercise conditions, the SDNN in females was significantly reduced (P=0.221) from the resting value of 62.6±7.9 to 56.9±8.0 (ms) while in males, there was no significant difference in SDNN in low intensity exercises (30%, 35% MVC), and high intensity exercise conditions (40%, 45%) (Table 2 / Figure 4).

Low Frequency (LF)

In Figure 5/ Table 3, there was no significant difference in LF in both genders in all isometric hand grip exercise conditions from the resting value of 21.5±2.2 to 34.3±2.1 (%) in males and from 14.6±2.1 to 23.7±2.6 (%) in females at 30% MVC respectively.

High Frequency (HF)

In Figure 6/ Table 3, there was no significant difference in HF in females in all isometric hand grip exercise conditions from the resting value of 10.5±2.0 to 5.5±1.8 (%) at 45% MVC and in males from the resting value of 12.4±3 to 16.2±2.9 at 40%MVC.

LF/HF

In Figure 7/Table 3, the LF/HF ratio increased significantly (p=0.0039) in females in all isometric hand grip exercise conditions from the resting value of 195.4±47.1 to 634.3±132.2 at 45% MVC. In the males, there was no significant difference in LF/HF from the resting value of 216.2±47.8 to 285.7±100.9 at 40% MVC respectively.

Very Low Frequency (VLF)

In Figure 8/Table 4, the resting values of VLF was higher in females (75.0±3.8 %) than in males (66.2±3.5 %) with no significant difference in to 59.4±4.9 % in males and 70.6±2.5 % in females at 40% MVC respectively.

Root Mean square of Standard Deviation (RMSSD)

In Figure 9/ Table 2, there was no significant difference in the RMSSD in both genders from the resting values of 43.6±9.9 to 27.2±6.0 (ms) in females and from 43.2±5.2 to 29.9±5.3 (ms) in males following different intensities of isometric hand grip exercise in all exercise conditions.

Proportion of NN50 (number of pairs of successive NN intervals) divided by total number of NN intervals (Pnn50)

There was no significant difference in Pnn50 in females from the resting value of 7.9±2.2 to 4.4±1.5 (%) at 45% MVC and in males from the resting value of 9.3±2.2 to 9.6±2.4 (%) at 30% MVC and to 4.2±1.4 (%) at 45% MVC respectively (Table 2/ Figure 10).

Total Frequency Power (TFP)

There was no significant difference in The TP (ms ^{2}) in both genders from the resting values of 6748.9±1227.5 to 3739.7±595.3 at 30%MVC in females and from 5783.2±872.0 to 3492.8±894.0 at 45% MVC in males respectively (Table 4).

DISCUSSION

In this study, the resting value of SBP was higher in males (118.7±3.3 mmHg) than in females (99.5±3.4 mmHg) which could be due to higher level of circulating catecholamine and enhanced cardiovascular responses in males when compared to females of the same age (Davis *et al*., 2000). Factors that may account for these differences are types of exercise, duration of exercise, and the level of physical activity of participants. We observed a significant rise in DBP (p<0.001) in both genders which agreed with studies of Laird *et al*. (1999) in 32 adolescents subjected to IHG at 25% MVC to exhaustion. However, studies of Surawics *et al.* (2001) and Palatine (2006) disagreed with this study by observing a reduction in diastolic blood. Factors that could account for dissimilarities in these studies are a) circadian rhythm – which accounts for increase in sympathetic markers, blood pressure and cortisol hormone in the morning (due to loss of cerebral autoregulation) and a decrease at night in subjects at rest (Frank *et al*., 2010). This study was conducted in the morning and late afternoon. b) Vasalva manoeuvre (VM) is an act of forceful exhalation against a closed glottis resulting in increased intrathoracic pressure (Forfia *et al., 2010*). During VM, there is a transient increase in SBP at its onset, a normal SBP when sustained, and a fall in SBP after its release (Forfia *et al., 2010)*. The deliberate holding of breadth observed during IHG exercise has been shown to increase B.P, and a slow breadth has been shown to reduce B.P (Funnelet *et al*., 2008). In this study, the respiratory rate of participants was not adequately monitored and

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controlled at normal rate of 12-15 breadths per minutes c) Race - elevated B.P and resting heart rate has been observed in Negroes compared to Caucasian (Michael *et al*., 2010; Judi and Joel, 1999). This has been linked to genetic factors and environmental factors. All participants in this study are of different races with majority being Africans d) Posture- BP increases while standing than in sitting position and reduces while in supine position in normal subjects (Mac William, 1933) due to hydrostatic effect on the legs. In this study, all readings were taken while participants were in upright sitting position e) duration and intensity of exercise- there was significant reduction in systolic and diastolic blood pressure by 12.5 mmHg and 14.9 mmHg in studies of Wiley *et al*. (1992) after performing 4 different hand grip exercise at 30% MVC for 2 minutes with a rest period of 3minutes for 8 weeks. However, studies of Umeda et al. (2010) observed a significant elevation in BP from the resting value after conducting 3 sessions of IHG exercise at 25% MVC lasting for 1, 3, and 5 minutes in one session. In this study, IHG exercise was done for a session at 30%, 35%, 40%, and 45% MVC respectively each lasting for 2 minutes with 10 minutes rest period. Thus, duration of exercise, intensity of exercise, and duration of rest period has significant roles in changes in blood pressure during and after exercise.

The resting heart rate is about 60-100 beats per minute (bpm) and it may increase to 150-160 bpm during exercise in both genders (Davis *et al*., 2000) due to increased sympathetic tone and reduced vagal tone associated with exercise. In this study, heart rate increased in males from resting value of 82.7 bpm to 91 bpm and in females from 84.7 bpm to 98.4 bpm. These values fall within normal range of resting heart beats from the above studies. Factors like prolong duration of rest periods (10 minutes) could account for the low values observed during exercise. However, there was a significant rise from resting values in both males and females during exercise with a greater significance in males ($p<0.001$) than females ($p<0.01$) due to higher level of adrenergic response experienced in males than their female counterpart (Davis *et al*., 2000). Studies of Ray and Carrasco (2000) differ from this study. They observed no significant difference in heart beats before 66 bpm (±SEM 4) and after 67 bpm (±SEM 4) 4 rounds IHG exercise in 9 trained, 7 sham trained and 8 untrained men at 30% MVC lasting for 3 minutes with 5 minutes rest period between contractions, four times in a week lasting for 5 weeks. This finding is like findings of Louhevaara *et al*. (2000) who observed no significant difference before (103bpm ±SD18) and after (102bpm ±SD 17) the hand grip exercise. In both studies, exercise lasted for weeks and there was reduction in number of heart beats. In this study, exercise was performed once with resultant increase in average number of heart beats.

The HRV is a good diagnostic marker for assessing the state of autonomic nervous function as it is currently used to assess autonomic changes with long- and short-term exercise in high performance training and leisure activity (Hottenrott *et al*., 2006). Low heart rate variability (HRV) has been associated with increased risk of mortality and has been proposed as a marker for some diseases (Thayer and Lane, 2007). High HRV indicates good adaptability and well-functioning autonomic nervous system. In this study, time domain of HRV was assessed by using SDNN (most valuable variant used in analysing HRV), Pnn50, and RMSSD. SDNN is a measure of total variability of the heart within recorded time and a measure of changes in heart rate in cycles longer than 5 minutes and shorter than 24 hours. We observed an initial increase in SDNN in males at 30% and 35% MVC then a decrease at 40% and 45% with a decrease in females in all exercise conditions, though not significant in both males and females. These variations could be because of

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the duration of exercise in our study (2 minutes) as compared with a minimum of 5 minutes proposed by Malik (2006). Our study differs from study of Gonzalez *et al*. (2000) who observed increase in SDNN from resting to isometric exercise in 10 male subjects performing static exercise at 30% MVC. Talk more on the time domains.

The frequency domain of HRV was assessed by LF and HF, LF/HF ratio, VLF, and TFP. LF is both parasympathetically and sympathetically mediated with a range of 0.01-0.15 Hz (Thayer *et al*., 2012). In this study, we observed an increase in LF from resting value of 21.5% (±SEM2.2) to 22.7% (±SEM2.1) in males and resting value of 14.6% (±SEM 2.1) to 20.6% (±SEM4.1) in females though not significant (p>0.05). Gonzalez *et al.* (2000) observed an increase in LF while performing IHG exercise at 30% MVC which differ from the results of our study. HF is primarily parasympathetically mediated, and it reflects respiratory mediated HRV at 0.15-0.40 Hz (Thayer *et al*., 2012). It increases with inspiration and decreases with expiration. From previous studies, it is assumed that HF is increased in females when compared to males. This is because of the enhanced vagal activity and less sympathetic control of the heart than men (Carter *et al*., 2003). We observed a contrary in this study with insignificant increase in HF in males by p>0.05 and insignificant decrease in females by p>0.05. Study of Winsley (2003) agreed with study of Carter *et al* (2003) in which continuous reading of HRV was performed on 12 children (7 males, 5 females). They found that HF significantly decreased in both genders from resting value during IHG exercise training. This may be attributed to the age of the participants (children) used in their study as it is shown that HRV increases with age (Gregoire *et al*., 1996). Factors that could account for the variation in our results when compared to other studies include a) Dominant hand- Studies of Clerke and Adams (2005) observed significant increase in sympathetic input and exercise performance in dominant hand by p<0.01 than non-dominant hand. In this study, this was not considered, all participants exerted pressure on hand grip transducer using the right hand. b) Hand grip strength appears to be greater in males than females, this accounts for high performance and cooperation with male participants than female participants. In this study, data from the male participant agree with other studies c) The errors in locating instant heart beats may result in errors in calculating HRV as it is very sensitive to artefact. Errors below 2% of the data could result in unwanted biases in HRV calculations. Hence, to ensure accurate results, it is critical to manage artifact and R-R errors appropriately prior to performing any HRV analyses. This was monitored in this study d) high number of participants (>30) produce a better reproducibility and analysis of data. In this study, 24 participants volunteered to participate out of which 19 participated e) type of instrument used in a study play significant role in the outcome of the study. We experienced some difficulties at the initial stage of our study with the polar watch's connection. This showed an error due to the poor connectivity of the polar watch with the transmitter and USB flash.

During this study and in interpreting the data, certain limitations may have to be well considered. Our findings may not be generalised to individuals with cardiovascular disease and future findings with trained participants and elderly may be dissimilar. IHG exercise was at different intensities of exercise while the difference was too close (30%-35%-40%-45%) showing a non-significant difference in variables especially HRV. Intensities at least 10% apart and duration of exercise (> 5 minutes) should be explored in future studies. Furthermore, more studies with large sample size are necessary to validate our findings.

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CONCLUSION

The result of this study revealed gender variations that occur in blood pressure and HRV during increasing intensities of IHG exercise with males showing greater significant increase in average number of heart beats, increase in HF indices of HRV; and females showing a greater significant increase in SBP and LF/HF ratio during increasing intensities of IHG exercise. Therefore, from our findings, we propose that males have higher parasympathetic influence while females have higher sympathetic influence of the autonomic nervous system with increasing intensities of IHG exercise.

TABLES AND FIGURES

Table 1: Effect of isometric hand grip exercise conditions on Blood Pressures in males and females

CONDITIONS	*SDNN (ms)*		*RMSSD (ms)*		*Pnn50 (%)*	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
Resting Value	*61.2±4.6*	*62.6±7.9*	*43.2±5.2*		*9.3±2.2*	*7.9±2.2*
30% MVC	*55.7±6.0*	*42.5±5.3*	*43.6±9.9*		*9.6±2.4*	*7.5±2.7*
35% MVC	*53.6±6.1*	*44.6±5.1*	*42.2±6.7*		*5.3±1.8*	*4.7±1.7*
40% MVC	*65.2±6.8*		*31.1±5.2*		*7.4±2.0*	*4.5±1.6*
45% MVC	*56.2±11.5*		*36.7±6.4*		*4.2±1.4*	*4.4±1.5*
	62.9±9.3	*56.9±8.0*	*29.7±4.0*			
			42.2±7.4			
			36.4±12.7			
			29.9±5.3			
			27.2±6.0			

* p<0.05 **p<0.01 ***p<0.001

Table 2: Effect of isometric hand grip exercise conditions on Time Domain of HRV in males and females

CONDITIONS	*SBP (mmHg)*		*DBP (mmHg)*	
	Males	*Females*	*Males*	*Females*
Resting Value	*118.0±3.3*	*99.5±3.4*	*73.6±0*	*69.7±0.0*
30% MVC	*132.7±2.8***	*112.6±5.0*	*88.9±3.3***	*80.6±3.2*
35% MVC	*131.6±3.0 **	*116.3±5.2***	*90.4±3.5****	*85.6±0.0***
40% MVC	*130.0±2.4*	*121.6±6.5****	*91.3±2.5****	*88.6±4.8****
45% MVC	*134.8±4.2 ***	*130.9±8.7****	*88.2±4.0***	*94.2±6.2****

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Table 3: Effect of isometric hand grip exercise on Frequency Domain of HRV in males and females

CONDITIONS	*HF (%)*		*LF (%)*		*LF/HF*	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
Resting Value	*12.4±2.3*		*21.5±2.2*	*14.6±2.1*	*216.2±47.8*	
30% MVC	*10.5±2.0*		*34.3±12.4*		*634.3±132.2*	
35% MVC	*16.2±2.9*	*8.6±2.3*	*23.7±2.6*		*185.5±48.0*	*401.6±94.4*
40% MVC	*14.0±3.0*	*9.9±3.3*	*22.7±3.2*	*18.6±2.8*	*245.4±47.5*	*257.0±38.2*
45% MVC	*13.8±2.3*	*7.7±1.5*	*26.8±4.0*	*21.8±2.4*	*415.3±101.1*	
	10.8±1.9	*5.5±1.8*	*22.7±2.1*	*20.6±4.1*	*285.7±100.9*	
					284.8±55.9	
					*195.4±47.1****	

**p<0.01

Table 4: Effect of isometric hand grip exercise on Frequency Domain of HRV in males and females

CONDITIONS	VLF (%)		TFP (ms^2)	
	Males	Females	Males	Females
Resting Value	66.2±3.5	75.0±3.8	5783.2±872.0	6748.9±1227.5
30% MVC	62.2±3.4	65.5±3.8	5351.1±1717.0	3739.7±595.3
35% MVC	63.3±5.1	71.5±5.4	4679.0±813.7	4697.5±1411.4
40 % MVC	59.4±4.9	70.6±2.5	4742.6±812.0	6451.6±3207.4
45% MVC	66.5±2.7	73.9±4.9	3492.8±894.0	4911.9±771.3

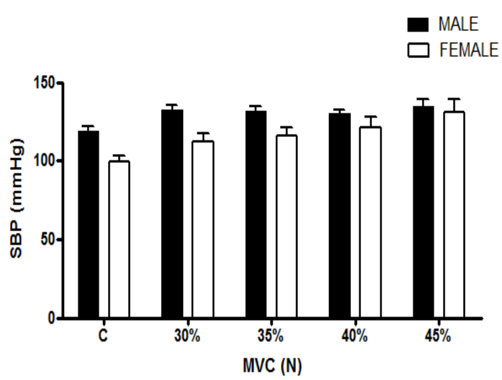

Figure.1. Systolic blood pressure against %MVC in males in males and females

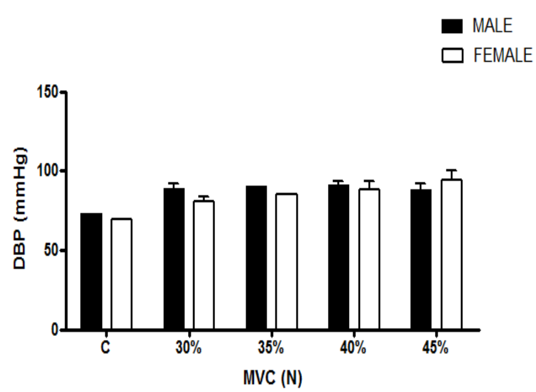

Figure.2. Diastolic blood pressure against % MVC and females

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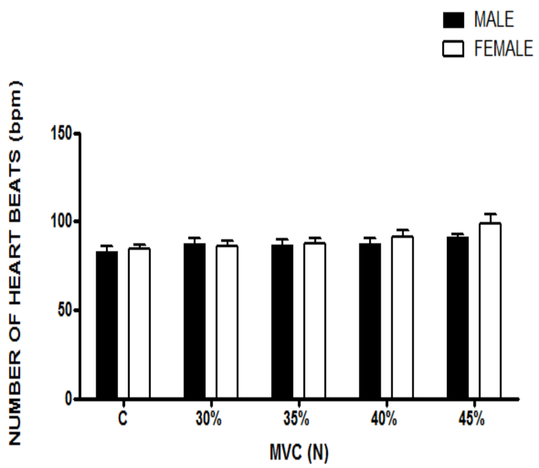


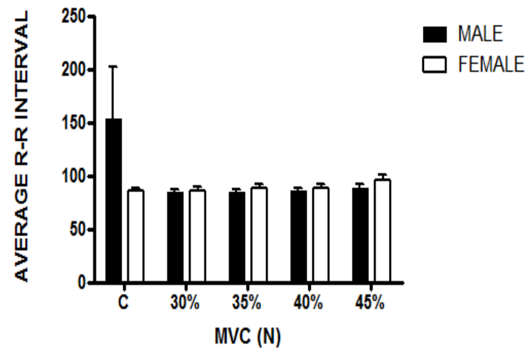
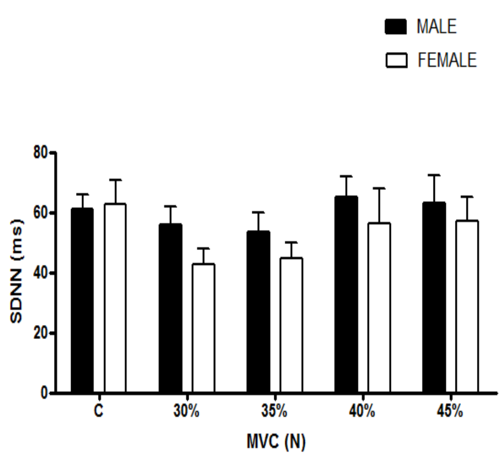


Figure.3. Average number of heart beats against % MVC
MVC in males and females

Figure.4. Average R-R interval against %
males and females



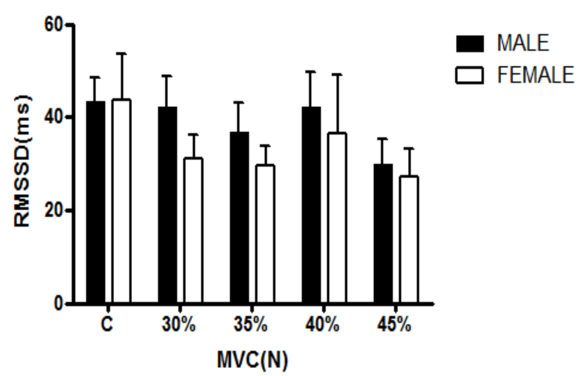


Figure 5. Standard deviation of NN intervals against
deviation %MVC in males and females

Figure 6. Root mean square of standard
against % MVC in males and females

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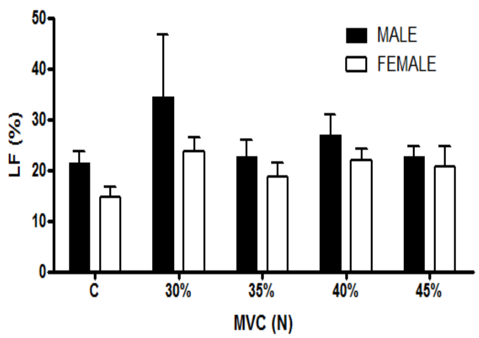


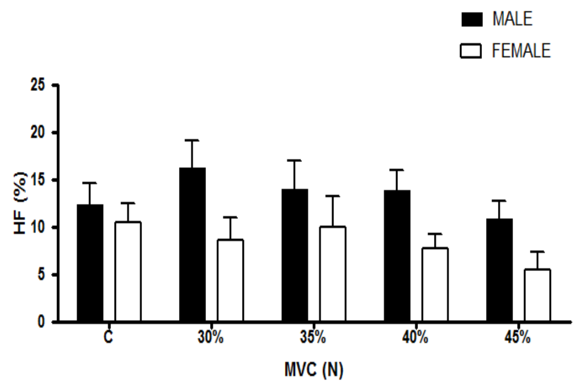
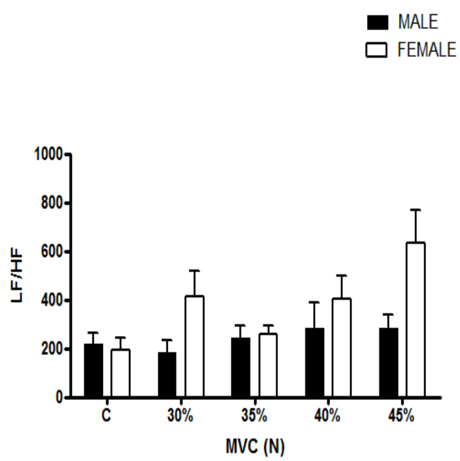


Figure 7. Low Frequency against % MVC in males in males and females

Figure 8. High Frequency against % MVC and females



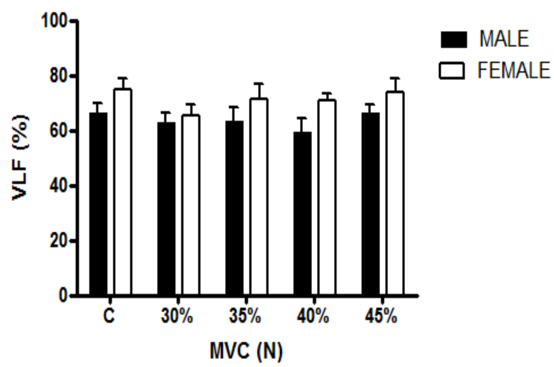


Figure 9. Low Frequency High Frequency ratio males and against % MVC in males and females

Figure 10. Very Low Frequency against % MVC in females

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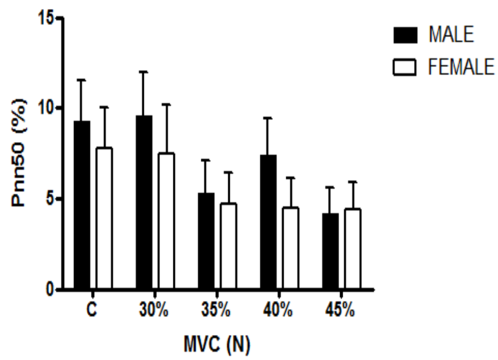

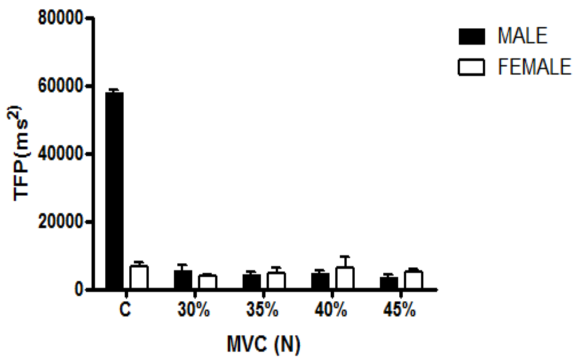

Figure11. Pnn50 against % MVC in males and females *Figure 12. Total Frequency Power against % MVC in males and females.*

Author's contribution

Dr Faatihah Niyi-Odumosu – Corresponding author, design, and ideas of creation of the study, collecting data and communicating with all participants, data analysis and interpretation.
Dr Mohammed Meah – project supervision, contribution to the ideas, and data interpretation

Conflict of interest

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