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# Sixty Minutes Post-Exercise Evaluation of Cardiovascular Responses in Normotensive Students of the University of Maiduguri, Borno State, Northeast Nigeria

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**Summary:** The study was aimed at providing a pattern of blood pressure decrease after an acute bout of exercise in normotensive subjects. A simple random sampling technique was used to select 138 apparently normotensive subjects (83 males and 55 females; age range 18-30 years), and the mean age was 22.28±0.52 and 19.84±0.28 in males and females, respectively. All participants were indigenes and undergraduate students of the University of Maiduguri, Borno State, Nigeria. The mean BMI was 23.29±3.80 kg/m and 19.07±2.42 kg/m in males and females, respectively. The mean resting SBP (118.65±1.52 and 105.6±2.14 in males and females, respectively), DBP (74.44±1.48 mmHg and 70.04±1.42 mmHg in males and females, respectively), and HR (83.92±2.63 bpm and 87.00±2.76 bpm in males and females, respectively) were recorded on their arrival. The mean SBP (145.28±2.67 mmHg and 123.64±1.97 mmHg in males and females, respectively), DBP (82.68±1.70 mmHg and 75.84±1.36 mmHg in males and females, respectively), and HR (112.96±3.08 bpm and 127.44±4.01 bpm in males and females, respectively) were recorded at 10 minutes of exercise. The study observed a significantly higher ($p < 0.05$) BMI in males than in females. Though BMI was positively associated with SBP at the end of 60 minutes into the recovery in males, the HR was negatively associated with BMI in females at 60 minutes into the exercise recovery. Meanwhile, such association was not seen in other parameters. The mean SBP, DBP, & HR at 10 minutes of exercise were all significantly higher ($p < 0.05$) than the resting state in both males and females. The decrease in the mean SBP, DBP, & HR after exercise was plotted against time for 60 minutes into the exercise recovery. A positive percentage change of SBP (22.56% and 17.18% in males and females, respectively), DBP (11.04% and 8.66% in males and females, respectively) and HR (34.41% and 45.37% in males and females, respectively) was seen at 10 minutes of exercise. A curvilinear pattern of SBP, DBP, and HR decline was observed at the end of 60 minutes. At the 3rd minute, the SBP in both males and females was already on baseline; DBP in males was slightly above baseline with a 2% positive change, while SBP in females was slightly below baseline. The SBP of male and female participants after the 3rd minute fell below baseline and remained persistently negative till the end of 60 minutes, with the female curve being far away from the baseline compared to male. The DBP in both males and females was on the baseline at the 14th and 15th minutes, respectively; the curve fell below baseline and remained persistent, but very close to the baseline. The curvilinear pattern of HR in both males and females showed a positive percentage but was above the baseline in both males and females. The study concluded that a typical curvilinear pattern of SBP crossed the baseline at the 3rd minute in both males and females, the magnitude of which is higher in females than in males; the DBP crosses at the 14th and 16th minutes and remained close to the baseline. Meanwhile, HR remained above the baseline. It is therefore suggested that SBP should be taken as a standard pattern for BP decrease during exercise..

**Keywords***: Post exercise, systolic and diastolic blood pressure, Heart rate, Normotensive, BMI, University of Maiduguri*

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## INTRODUCTION

Physical activity is recommended for both prevention and diagnosis of cardiovascular diseases. It has also been applied in the management of high blood pressure in particular (Guidelines committee 2003; Pescatello *et al*, 2004). During exercise a dramatic increase in systolic and diastolic blood pressure have been reported and the extent of these increase depend on the time and intensity of the exercise (Stone *et al*., 1991). Immediately following a period of dynamic exercise, blood pressure decreases (Ressl *et al*., 1977). The duration for the decrease in systolic blood pressure and diastolic blood pressure may be as much as 30 minutes after exercise at 30 and 18mmHg in normotensive subjects and 45 and 24mmHg in hypertensive subjects

(Wilcox *et al*.,1982). Therefore the optimal gold of interest is the importance of studying cardiovascular recovery from exercise. This recovery may not be simply returning to pre-excercise period rather it could be seen as dynamic period where many physiological changes can occur. Thus, it could be argued that recovery from exercise should also be seen as important as exercise stimulus. As already described by luttreel and Halliwill (2009), the recovery from exercise can be viewed as a vulnerable period in which individuals are at heightened risk for adverse events or window of opportunity for adaptation in which training can be potentially augmented. Furthermore, it may also provide insight into when the cardiovascular system recovers.

The cardiovascular system after exercise exists in a physiological state which differ from rest and exercise. During dynamic exercise systolic blood pressure increase linearly with increasing rates of work reaching a peak value (Plateau) of 200mmHg and 240mmHg and negative drift in normotensive persons. This increase is brought about by the increase in cardiac output and would have even be higher if not for the fact that resistance decreases thereby partially offsetting the increased cardiac output and as a result of reseting the arterial baroreflex to a higher point. However, diastolic blood pressure does not change or change so little that it has no physiological significance. The mechanism adjusts blood pressure, heart rate and systemic vascular resistance is being reported to be mediated reflexly by modulating sympathetic and parasympathetic tone to the heart and vessels on the bases of the mechanical and metabolic status of working muscles (Nobrega *et al*.,2014; Crisafulli, 2017)

It is obvious that cardiovascular responses could be viewed at two stages; during exercise and after exercise, the mechanism which are totally different from that obtained during resting stage. The blood pressure and heart rate takes a shorter duration to reach a peak, averagely the first 1-2 minutes of exercise whereas the recovery from exercise take several hours as recognised early in Hill's initial observation of blood pressure responses following aerobic exercise (Romero *et al*.,2017). The longer duration for the cardiovascular system to return to pre-exercise state stimulate the use of exercise in the management of high blood pressure. More so excercise testing, a way of challenging cardiovascular to physical stress, could reveal abnormalities that are not present at rest and can be used to predict adequacy of cardiac function (Gisler *et al*., 2007). Even in hospital setting, application of exercise testing has been proved to be effective in the diagnosis of some underlying CVS problems with focus on post-exercise recovery. Several reports have revealed that blood pressure decrease below normal level in normotensives without giving a specific patterns of how the decrease was obtained. Therefore evaluation of this pattern is necessary and may also serve as a standard border line between the normal and abnormal responses.

## MATERIALS AND METHODS

**Participants:** A total number of 138 Participants (83 males and 55 females) were recruited for this study, after satisfying the inclusion criteria. This population sampling was based on a previous study that prevalence of normotensives is 90.6% between the ages of 18 to 30 years residing in Maiduguri, Borno state, Nigeria (Aliyu *et al*., 2015). Based on this finding, we assumed that the prevalence of normotensive subjects between that age range, should be applied to the students of the University of Maiduguri. The participants were selected amongst the undergraduate students of the University of Maiduguri, using a simple random sampling technique to participate, to determine Systolic blood pressure, Diastolic blood pressure, Heart rate and Body Mass Index.

All participants recruited for this study were non-athletes, non-smoking students of the university of Maiduguri with no history of cardiovascular and respiratory diseases, absence of use of any medications, including birth control pills. The female participants were not neither pregnant nor menstruating at the time of the study. The procedures of the study were explained to the participants and their verbal and written consents were obtained before participation. Approval was taken from the Health Research Ethics Committee of the University of Maiduguri.

**Procedures:** The criteria for selection for the participants were based on their responses to Questionnaire. Each participant was asked not to participate in any competitive sports or medication 48 hours prior to the appointment day for the exercise, other than daily normal activities. The venue of the data collection was at the Physiology Laboratory, Department of Human Physiology, University of Maiduguri.

On arrival at the venue, each participant was allowed to rest for at least 30 minutes to obtain BP and HR resting values. Measurements of height and weight was first carried out using a stadiometer (Sz-200, Suzhou Sike Machinery Equipment Co., Ltd, Suzhou Jiangsu China) and digital weighing scale (Vins Medical, England) respectively, before the commencement of the exercise testing. The Body Mass Index (BMI) was calculated from the values obtained from height and weight using the following formula,

$$BMI = \frac{Weight(Kg)}{Height(m^2)}$$

**Systolic blood pressure, Diastolic blood pressure and heart rate measurements:** Resting Systolic blood pressure, Diastolic blood pressure and heart rate was measured thrice and average was recorded before the onset of the exercise. A standard digital automated BP device (Omron, HEM-7120-E) was used while the subject was in a sitting position, to measure the Systolic blood pressure, Diastolic blood pressure and Heart rate. Duracell batteries was used for the device, which was renewed after each session with a subject.

**Training protocol:** Bruce *et al* (1976) protocol was employed in carrying out the exercise performance. Briefly, the participants were subjected to 10 minutes exercise on a stationary cycle ergometer, fixed at a speed of 10.5mph. This was in line with previous research work (Myers, *et al*., 1994) that maximal exercise capacity could be reached at approximately 10 minutes.

At the end of the 10 minutes exercise session, the Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured immediately. After that, this was followed by SBP, DBP and HR measurements at 2 minutes and 3 minutes into recovery. Subsequently, the SBP, DBP and HR were taken at intervals

of 2 minutes for a duration of 1 hour to get the pattern or curve of decrease of SBP, DBP and HR after exercise.

**Data Analysis:** The data obtained were analysed using Statistical Package for Social Sciences (SPSS) version 16. All results were expressed as Mean ± SEM, Independent t-test was used to compare between the means of SBP, DBP and HR response to exercise between male and female groups and analysis of Variance (ANOVA) was used to calculate difference between the mean. Mean percentage increase in SBP, DBP, and HR in male and female was compared immediately after 10 minutes of exercise. A correlation analysis was used to establish a level of association between BMI and SBP, DBP and HR immediately after 10 minutes of exercise and 60 minutes into exercise recovery, Significant level was taken at P< 0.05. The mean percentage change of SBP, DBP and HR for male and female were plotted against time of exercise recovery.

**Calculation of percentage change:**The following formular was use d to calculate the percentage change:

$$\frac{New\ value - original\ value}{original\ value} \times 100\%$$

If the result is positive it indicates that BP and HR is above resting value, and if the result is zero, the BP and HR is on resting value. However, if the result is negative, BP and HR is below resting value (Madhuri, 2022)

## RESULTS

**Anthropometric indices and Baseline Values of SBP, DBP and HR of the recruited participants:** The participants recruited into this exercise were 150, comprising 91males and 59females, they were satisfied with the inclusion criteria of the study. The age range of the participants is between 18-30years with their mean age of 22.28±0.52 years and 19.84±0.28 years for male and female respectively. During the course of the exercise, we observed that only 138 subjects (83males and 55females) were eligible to be included. This was based on abnormal response that was recorded in 12 of our participants (8 males and 4 females). Further investigation from these 12 participants confirmed that they actually participated in one or more forms of exercise. The mean weight (kg), height (m) and BMI (kg/m2) were 64.38±2.26kg, 1.73±0.01m and 23.29±3.80kg/m2 in male, while in female were 50.44±1.43kg, 1.58±0.01m and 19.07±2.42kg/m2 respectively. The recorded mean systolic blood pressure (mmHg), diastolic blood pressure (mmHg) and heart rate (bpm) at the onset of the exercise were 118.65±1.52mmHg, 74.44±1.48mmHg and 83.92±2.63bpm respectively in male while in female were 105.60±2.14mmHg, 70.04±1.42mmHg & 87.00±2.76bpm respectively (Table 1a).

**Table 1a:**
Anthropometric indices and Baseline values of SBP, DBP, and HR of recruited participants

| Variables | Male (n=83) Mean ± SEM | Female (n=55) Mean ± SEM |
|---|---|---|
| **Age (years)** | 22.28±0.52 | 19.84±0.28 |
| **Weight (Kg)** | 64.38±2.26 | 50.44±1.43 |
| **Height (m)** | 1.73±0.01 | 1.58±0.01 |
| **BMI (Kg/m$^2$)** | 23.29±3.80 | 19.07±2.42 |
| **Systolic (mmHg)** | 118.82±0.89 | 105.56±1.37 |
| **Diastolic (mmHg)** | 74.60±0.81 | 69.93±0.97 |
| **Heart Rate (Bpm)** | 84.15±1.43 | 87.20±1.80 |

The values are presented as Mean±SEM

**Baseline Mean values of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Heart rate (HR) and at 10minutes of exercise in male and female:** The effect of 10 minutes exercise showed that the baseline mean Systolic Blood Pressure, Diastolic Blood Pressure and Heart Rate increased from 118.65±1.52mmHg, 74.44±1.48mmHg and 83.92±2.63bpm respectively to 145.28±2.67mmHg, 82.68±1.70mmHg and 112.96±3.08bpm respectively in male. On the other hand, the same observations were made in female, the mean Systolic Blood Pressure, Diastolic Blood Pressure and Heart Rate from 105.60±2.14mmHg, 70.04±1.42mmHg and 87.00±2.76bpm respectively to 123.64±1.97mmHg, 75.84±1.36mmHg and 127.44±4.01bpm respectively (Table 1b).

**Table 1b:**
Baseline Mean values of Systolic Blood Pressure, Diastolic Blood Pressure, & Heart rate and after 10minutes of exercise in male and female

| Parameters | Systolic Blood Pressure (mmHg) | | Diastolic Blood Pressure (mmHg) | | Heart Rate (bpm) | |
|---|---|---|---|---|---|---|
| Gender | Base line | After 10mins | Base line | After 10mins | Base line | After 10mins |
| **Male (n=83)** | 118.82±0.89 | 145.63±1.54 | 74.60±0.81 | 82.92±0.92 | 84.15±1.43 | 113.10±1.62 |
| **Female (n=55)** | 105.56±1.37 | 123.69±1.30 | 69.93±0.97 | 75.98±0.90 | 87.20±1.80 | 126.76±2.62 |

The values are presented as Mean±SEM

**Mean percentage increase in Systolic Blood Pressure, Diastolic Blood Pressure, & Heart Rate in Male and Female immediately after 10minutes exercise:** Table 2 shows the mean percentage increase in Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Heart Rate (HR) in both male and female immediately after 10minutes of exercise. It was observed that the mean percentage increase in SBP (22.9 ±0.12%) and DBP (11.4±0.07%) was significantly higher (P<0.05) in male than in female (17.6 ± 0.083%) and (8.66±0.07). However, contrary to what was observed in male SBP and DBP, the mean percentage increase in female Heart Rate (46.8 ± 0.22%) was significantly higher than the HR (35.6 ± 0.148%) in male.

**Level of association between Basal Metabolic Index (BMI) and Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Heart Rate (HR) at 10minutes and 60minutes into the exercise recovery:** Table 3 shows the level of association between mean BMI,

SBP, DBP and HR at 10 minutes of exercise and 60 minutes recovery into the exercise. No significant association between BMI and increase in SBP in both male and female, which means that the increase in SBP observed at 10 minutes exercise does not associate with BMI. However, at 60 minutes into the exercise recovery, positive association between BMI and decrease in SBP in male was recorded, though the recorded increase in DBP at 10 minutes exercise and decrease in DBP at 60 minutes into the recovery of exercise shows no significant (P<0.05) association in both male and female. Meanwhile HR, at 10 minutes of exercise showed no significant association in both male and female while significant association at 60 minutes of recovery in female was observed, this association was not observed in male.

**Effect of Exercise on Systolic Blood Pressure (SBP) Systolic Blood Pressure (SBP) during one-hour after exercise in male:** Figure 2a shows SBP baseline, and at 10 minutes of exercise followed by gradual decrease with time for a duration of 60 minutes in male. It was noted that the mean SBP at rest significantly rise (p<0.05) from 118.65±1.52mmHg to 145.28±2.67mmHg at 10 minutes of exercise. This mean value (SBP 145.28±2.67mmHg) was significantly decreased to 124.04±2.26mmHg at 2 minutes, the calculated percentage change at 2 minutes into the exercise recovery with respect to the resting SBP was positive (4.70%), while at 3rd and 4th minute the percentage changes were essentially negative with -0.40% and -0.66% respectively.

**Table 2:**
Mean percentage increase in Systolic Blood Pressure, Diastolic Blood Pressure, & Heart Rate in Male and Female immediately after 10minutes exercise

| | Percentage Increase (%) | | |
|---|---|---|---|
| **Variables** | **SBP (mmHg)** | **DBP (mmHg)** | **HR (bpm)** |
| **Male (n=83)** | 22.56 ±0.12 | 11.14 ± 0.07 | 34.41 ± 0.14 |
| **Female (n=55)** | 17.18 ± 0.08 | 8.66 ± 0.07 | 45.37 ± 0.22 |
| **Mean difference** | 5.30 | 2.48 | -10.96 |
| **P-value** | P<0.001 | P<0.001 | P<0.001 |

The values are presented as Mean ± SEM, values of P<0.05 are statistically significant between compared groups.

**Table 3:**
Level of association between BMI and Systolic Blood Pressure, Diastolic Blood Pressure and Heart Rate immediately after 10 minutes and 60 minutes after exercise

| Variable | SBP after 10 mins exercise | SBP after 60 mins exercise | DBP after 10 mins exercise | DBP after 60 mins exercise | HR after 10 mins exercise | HR after 60 mins exercise |
|---|---|---|---|---|---|---|
| Male | -0.0360$^{NS}$ | 0.2661* | -0.0628$^{NS}$ | -0.1295$^{NS}$ | 0.0222$^{NS}$ | -0.0260$^{NS}$ |
| Female | 0.2629$^{NS}$ | 0.0826$^{NS}$ | 0.1025$^{NS}$ | -0.1071$^{NS}$ | 0.0721$^{NS}$ | -0.3433 |

Note: *, NS are Significant and not significant respectively (p<0.05

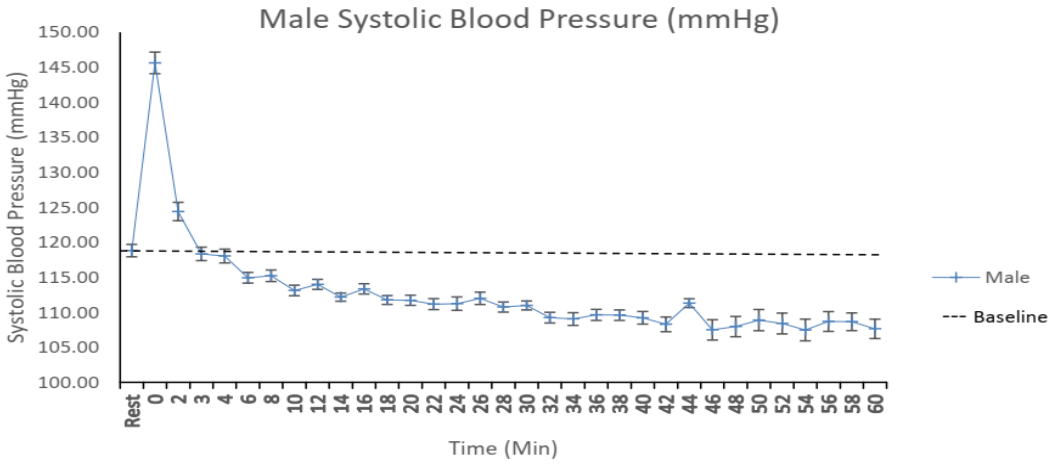


**Figure 2a:**
Graphical presentation showing male SBP pattern one hour Post Exercise

There after the curve showed a gradual increase in negativity except at 16th and 44th minutes into the exercise recovery when a sharp decrease negativity change was recorded. At the end of the 60th minute the negative percentage change was high (-9.41%).

**Systolic Blood Pressure (SBP) during one-hour after exercise in female:** Figure 2b show SBP baseline and at 10 minutes of exercise followed by gradual decrease with time for a duration of 60 minutes in female. The mean SBP significantly rise (P<0.05) from 105.6±2.14mmHg at rest to 123.64±1.97mmHg at 10 minutes exercise. The mean rise in the SBP suddenly decrease to 110.12±1.99mmHg at 2 minutes, the calculated percentage change at 2 minutes into the exercise recovery was positive (4.36%) with respect to resting SBP while at 3rd and 4th minutes the percentage changes were negative. The curve thereafter showed a gradually increased negativity except at 22nd, 32nd, 45th minutes into the exercise recovery, was less negative with respect to the resting SBP. The study also noted that the percentage changes of SBP at the end of 60 minutes was -7.02%.

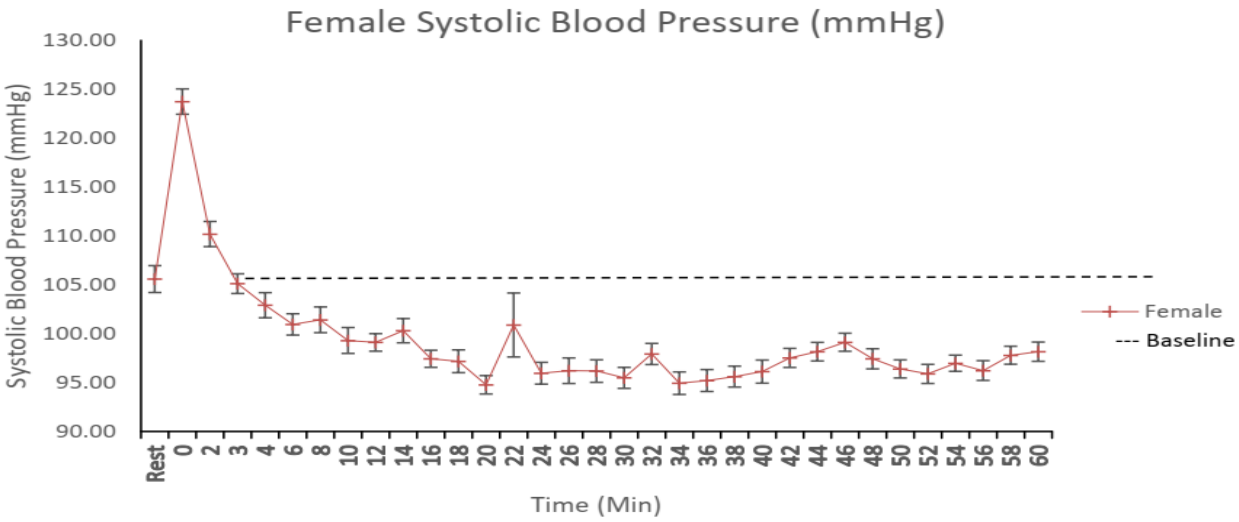


**Figure 2b:**
Graphical presentation showing Female SBP pattern one hour Post Exercise

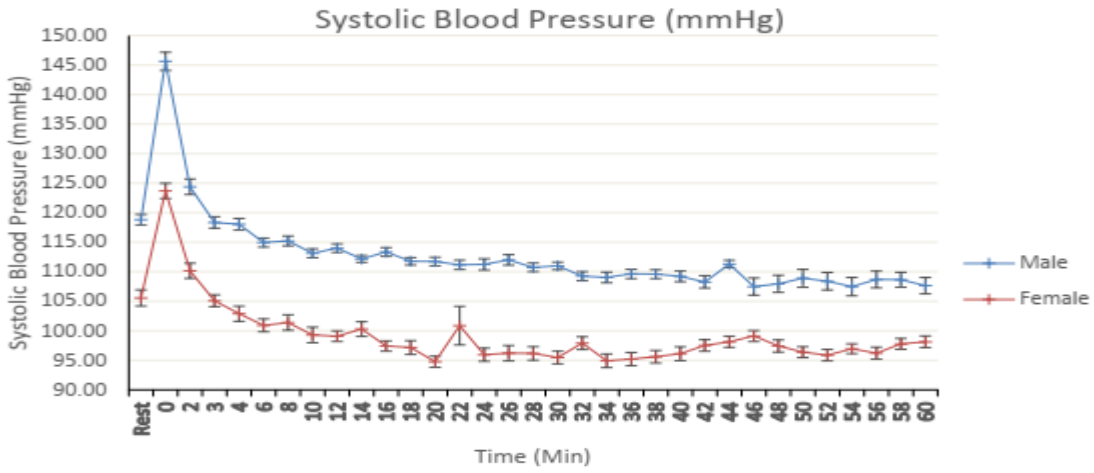


**Figure 2c:**
Graphical presentation showing comparison between patterns of SBP Decrease in male and female Post exercise

**Comparison between patterns of Systolic Blood Pressure (SBP) decrease after 10 minutes of exercise in male and female:** The graph shows a high positive mean SBP changes in male compared to female (22.05% and 17.18%) respectively. The mean positive percentage change of SBP was also noticed to be higher in male than in female at 2 minutes into the exercise recovery in respect to the resting SBP. Both curve (male and female) showed zero negative percentage at 3rd minute into the exercise recovery. The zero percentage change was gradually followed by increased negativity with male recorded highest negative change compared to female.

**Effect of Exercise on Diastolic Blood Pressure (DBP)**
**Diastolic Blood Pressure (DBP) during one-hour after 10 minutes of exercise in male:** Figure 3a show DBP baseline, and at 10 minutes of exercise followed by gradual decrease with time in male. An initial significant ($p<0.05$) increase of DBP (74.44±1.48mmHg) at rest to (82.68±1.70mmHg) at 10 minutes of exercise, representing a positive percentage change of 11.14% with respect to the resting DBP. At 2 minutes into the exercise recovery the percentage change was also positive (4.20%), thereafter there was a gradual positive percentage decrease and at 14th minute into the exercise recovery the percentage change was zero. The zero percentage was accompanied by gradual decrease of negative percentage changes and at 60 minutes into the exercise recovery the percentage change was -4.44%.

**Diastolic Blood Pressure (DBP) during one-hour after 10 minutes of exercise in female:** Figure 3b show DBP baseline and at 10 minutes of exercise followed by gradual decrease with time in female. The female DBP showed a statistically significant ($p<0.05$) increase at 10 minutes of exercise from (70.04±1.4mmHg) to (75.84±1.36mmHg), representing 8.66% positive percentage change, with respect to resting DBP. Then the result also recorded a decrease positive percentage change at 2 minutes (5.25%), however at 3rd minutes of recovery a negative (-1.30%) percentage change was noticed. A rebound positive percentage change was seen at 4th, 6th, 8th, 10th, 12thand 14th minutes into the exercise recovery. Whereas at 16th minutes into the recovery the percentage change was negative which was accompanied with gradual increase in negative percentage change till the end of the 60 minutes into the exercise recovery (-6.21%) as showed in figure 3b.

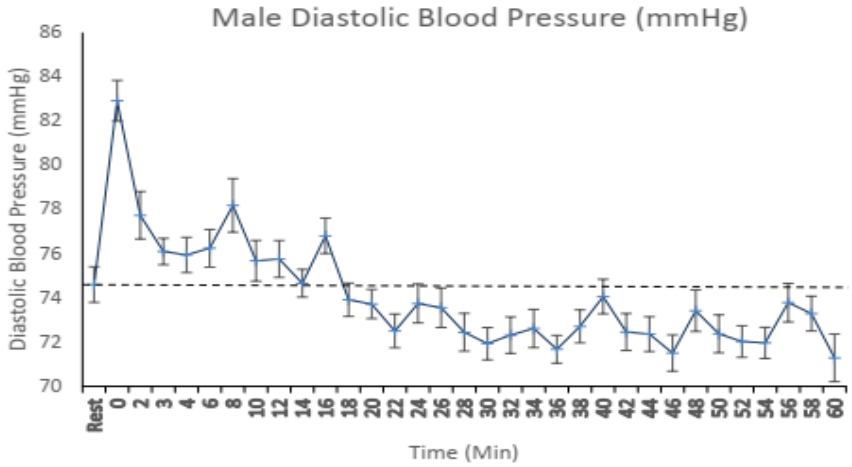


**Figure 3a:**
Graphical presentation showing male DBP pattern one hour Post Exercise

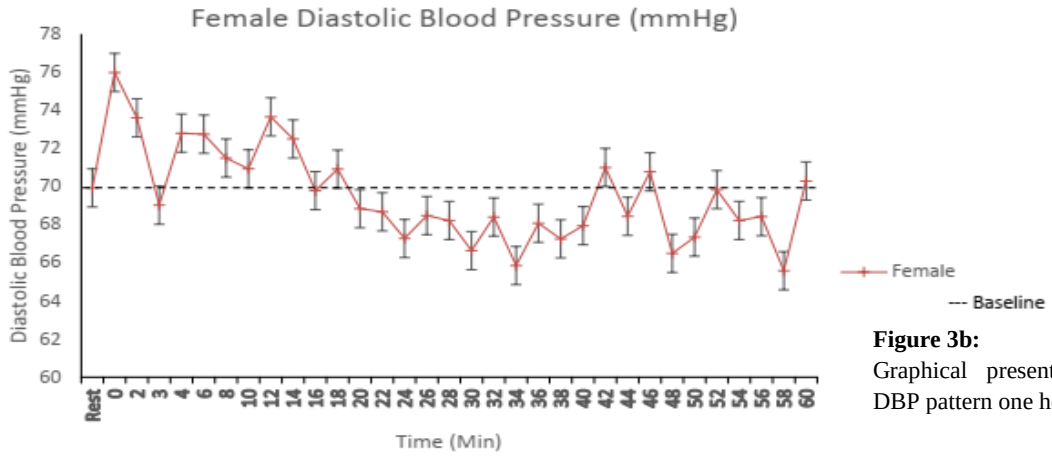


**Figure 3b:**
Graphical presentation showing Female DBP pattern one hour Post Exercise

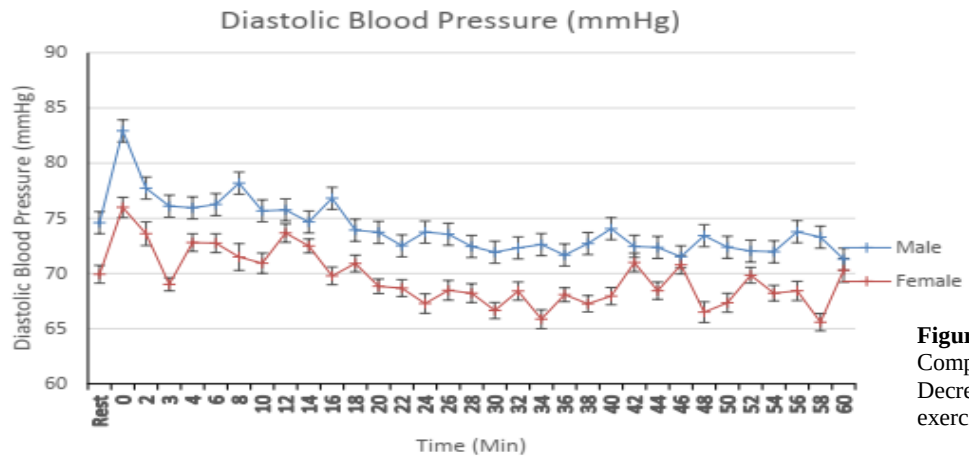


**Figure 3c:**
Comparison between patterns of DBP Decrease between male and female Post exercise

**Comparison between patterns of Diastolic Blood Pressure (DBP) decrease after 10 minutes of exercise in male and female:** Figure 3c show the comparison of the pattern of DBP decrease in male and female during 60 minutes after 10 minutes of exercise. A higher positive percentage changes of DBP in male (11.4%) compared to female (8.66%) was recorded at the end of 10 minutes of exercise in respect to the initial DBP. While a gradual decrease in positive percentage changes till percentage changes was negative at 14th minute into the recovery of exercise in male, the female counterpart showed a negative change at 3rd minute into the recovery followed by rebound positive change that terminated by negative changes at 16th minutes into recovery. The result also noticed the percentage negative change failed to return to zero percentage change (baseline) before exercise in both male and female.

**Effect of Exercise on Heart Rate (HR)**

**Heart Rate (HR) during One-Hour after 10 minutes of exercise in male:** Figure 4a show HR baseline and at 10 minutes of exercise followed by gradual decrease with time in male. At 10 minutes of exercise, the HR significantly ($p<0.05$) rise from resting 83.92±2.63bpm to 112.96±3.08bpm. The calculated positive percentage change was 34.41% in respect to the initial resting state. The heart rate gradually declined with time but fail to return to resting HR at the end of sixty minutes.

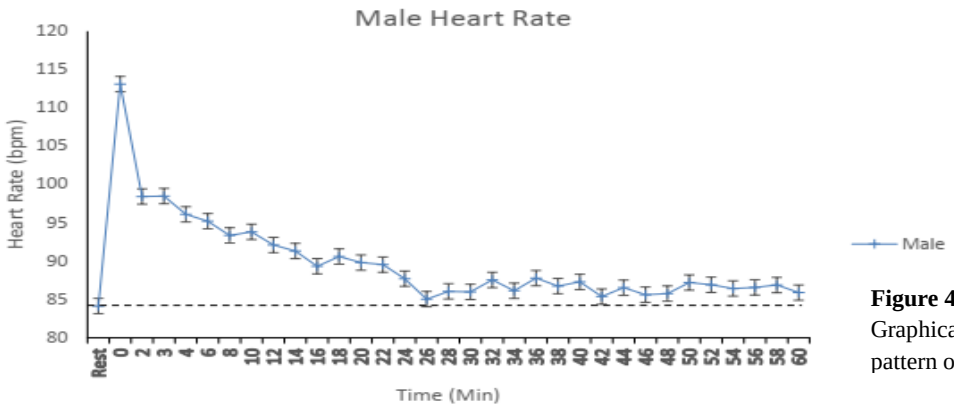


**Figure 4a:**
Graphical presentation of Male Heart Rate pattern one hour Post Exercise

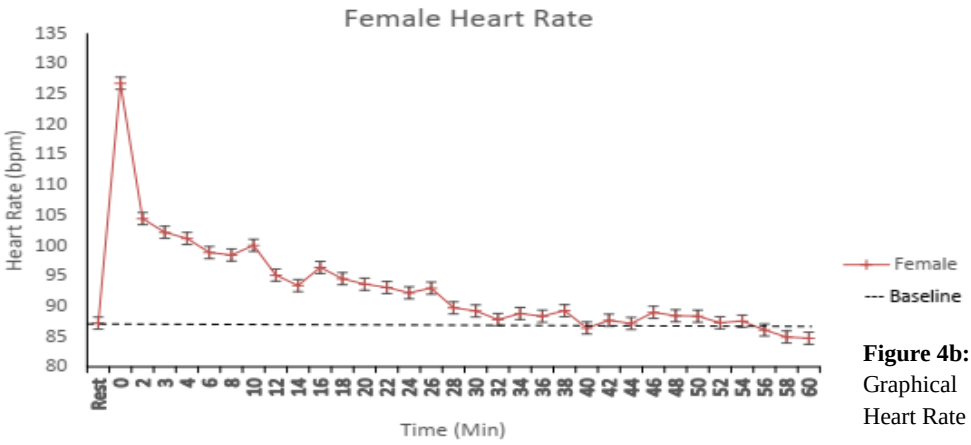


**Figure 4b:**
Graphical presentation showing Female Heart Rate pattern one hour Post Exercise

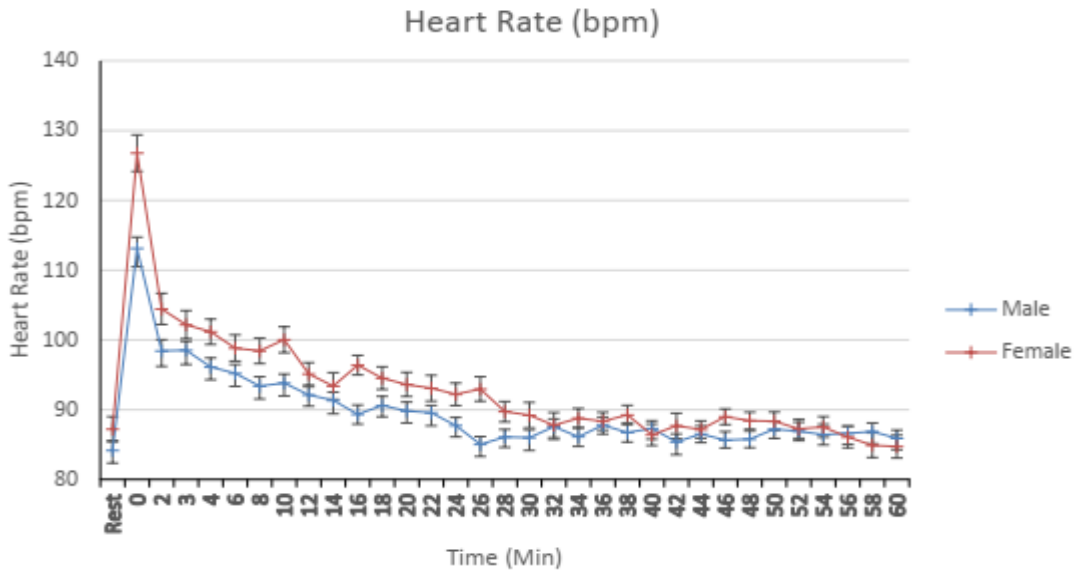


**Figure 4c:**
Graphical presentation showing comparison between patterns of Heart Rate Decrease between Male and Female Post exercise

**Heart Rate (HR) during One-Hour after 10minutes of exercise in female:** Figure 4b show HR baseline and at 10 minutes of exercise followed by gradual decrease with time in female. At 10 minutes, there was a significant ($p<0.05$) rise of HR from resting (87.00±2.76bpm) to 127.44±4.01bpm, representing a positive percentage change of 45.37%. Following this sharp increase, the heart rate gradually declined with time, and a negative percentage change was noticed at 40th minutes indicating that baseline of the HR was reached at that time into exercise recovery. Further negative change was also recorded with time and remained negative till end of sixty minutes in respect of resting HR level

**Comparison between patterns of decrease of Heart Rate (HR) after 10minutes of exercise in male and female:** A comparison of graphic representation in male and female showed a sharp rise with female having a higher percentage increase of 45.37%, while male have 34.41%. The comparison also showed that 19.77% positive percentage

change was recorded at 2 minutes into recovery in female, only 16.98 percent was seen in male. A gradual decline in positive percentage change was recorded in both male and female however the female showed a negative percentage change at 40 minutes into recovery in respect to resting HR. Meanwhile, the female also showed a slight negative change below resting HR level the male counterpart shows slight positive change above resting HR.

## DISCUSSION

Evaluation of aerobic dynamic exercise testing of normotensive, non-athlete and apparently healthy participants studying at the University of Maiduguri, for the purpose of determination of pattern curve that could be used as a standard, and equally represent a normal Cardiovascular response to exercise challenges for diagnosis. Therefore, pre-exercise and post-exercise baseline and other parameters influencing cardiovascular dynamic change in health and disease condition were studied carefully following ten minutes (10 minutes) of aerobic exercise. This study showed the mean age of male and female subjects age range between eighteen years (18years) to thirty years (30 years) were 22.28±0.52 and 19.84±0.28 respectively, indicating female subjects attending University of Maiduguri after 20years were fewer compared to male. This finding support the culture of marrying off young female before the age of 20years, and exclusion of married female may explain the discrepancy of the mean age of male and female in this study.

The recorded body mass index in both subjects show a significantly higher BMI in male compared to the female counterpart. Though no association between BMI and mean systolic blood pressure recorded from both male and female age range 18-30years at 10minutes of exercise, positive association of BMI and decrease in SBP seen in male at end of sixty minutes (60 minutes) into the recovery. Meanwhile, such association was not recorded in female. This study supports the general view that both systolic and diastolic blood pressure were higher in male compared to the female (Afrifa-anane *et al*., 2015), which could probably be the reason why prevalence of hypertension is higher among men than women (Cappuccio *et al*., 2004). This discrepancy could also be seen as supportive of genetic, endocrine and body composition differences between sexes (Bassareo and Crisafulli., 2020). Interestingly, the level of association between BMI and increased DBP at 10 minutes, and its decrease at 60 minutes of exercise recovery was not seen in both male and female indicating DBP is less considered in exercise testing. More so, the study also recorded no significant association between BMI and increase HR at 10 minutes of exercise in both sexes. However, at 60 minutes into exercise recovery while male showed no significant association, female show a negative significant association in HR at end of sixty minutes (60 minutes) of exercise recovery, the phenomenon attributed to a greater parasympathetic activity towards the heart as well as less sympathetic input to vascular regulation in women than in men (Raemakers *et al*; 1998; Fisher *et al*; 2013). This could probably be the reason why female have a significant high resting heart rate as it was observed in this study.

A sudden rise in Systolic blood pressure was recorded at the end of ten minutes (10 minutes) of exercise in both male and female. This phenomenon is consistent with other researchers work that dynamic exercise like in our case is characterized by an increase in mean arterial blood pressure notwithstanding the marked systemic vascular resistance reduction due to the metabolic induced vasodilation (Crisafulli *et al*; 2006). A neural mechanism that is responsible for the fine haemodynamic regulation that guarantees blood supply to exercising muscle and avoids excessive mean arterial blood pressure could be implicated. This neural mechanism includes: - 1. Central command 2. exercise pressure reflex and 3. arterial baroreflex, were identified by Green and Paterson (2008) and Nobrega *et al* (2014) as causes of increased blood pressure during exercise. Therefore, the increase in systolic blood pressure are brought about by the increase in cardiac output as a result of increased in heart rate. Meanwhile no significant changes in diastolic blood pressure was recorded in both male and female; supporting other research finding of lack of significant changes in diastolic blood pressure, which was attributed to peripheral vasodilatation in active muscle thereby increases blood flow and availability of oxygen and nutrient. (Romero *et al*., 2017)

A high percentage systolic blood pressure increase recorded in male compared with female is consistent with studies of Dimpka *et al*. (2008). They attributed it to blunt sympathetic response and higher vasodilatory state of women in comparison with men (Wheatley *et al*., 2014). In contrast, higher percentage increase of heart rate was seen in female compared to its male counterpart supporting the studies of Astrand *et al*. (1964), which attributed it to lower parasympathetic outflow to female heart to compensate for lower stroke volume, thereby resulting in the higher cardiac output. Whereas, female sexual hormone also exerts relaxing effect on peripheral resistance (Li and Kloner, 1995; Kaur *et al*., 2015). The study also recorded lower diastolic blood pressure in female compared to male counterpart at the end of 10 minutes exercise supporting the evidence of reduced vasoconstriction and lower vascular resistance in female (Bassareo and Crisafulli, 2020).

Sixty minutes monitoring of systolic blood pressure after ten minutes of exercise showed a typical curvilinear pattern. Subsequent to initial rise of SBP from normal resting systolic blood pressure to a peak at ten minutes of exercise approximately 22.9±0.12% in male and 17.6±0.85%in female of increase, a sharp decline was first seen at two minutes into the exercise recovery. A positive percentage change of 4.7% (representing a higher SBP in respect to resting SBP) in male was noticed at two minutes into the exercise recovery, while female SBP showed an initial decline of positive percentage change (4.36%) at 2 minutes. However, both male and female demonstrated a zero negative percentage change at 3 minutes indicating that SBP has returned to baseline value. This finding support the view that attainment of resting value of SBP could be reached within five minutes post-exercise (Taylor and Bellar, 1998). The importance of determining the percentage decline of SBP after aerobic exercise lies on its usefulness in the assessment of cardiovascular responses to physical stress (Dimpka *et al*., 2008). More so, Miyai *et al*. (2002), asserted that the magnitude of an exercise-induced SBP response may present a risk for death from cardiovascular and non-cardiovascular causes, independent of resting blood pressure. Also a number of research work established an

association between delay recoveries of SBP (Taylor and Bella, 1998) and heart rate (Mora *et al*., 2007) to the resting levels and the presence and extent of heart diseases. Subsequent to the attainment of baseline value of SBP, the graph curve showed a linear gradual persistent negative (indicating that the Systolic blood pressure remained below resting value) percentage change, which is more far away from baseline in female compared to male until the end of 60 minutes. The persistent negative percentage change which is an indication of SBP below resting value, corresponds and support the view of post-exercise hypotension as reported by various research work (Cardoso *et al*., 2010; Halliwill *et al*., 2013), a phenomenon attributed to the liberation of vasodilation substance at site of active muscle (Halliwill, 2001). However, the differences observed in SBP responses during 60minutes of recovery in both sexes could be reflection of structured hemodynamic differences between male and female during recovery from dynamic exercise in which female have been reported to exhibit a reduced capacity to vasoconstriction of the arteriolar bed as compared to men (Bassareo and Crisafulli, 2020). Other studies observed that the decrease in pressure during recovery after dynamic effort is greater in female than in male (Carter *et al*; 2001). Meanwhile, other studies (Christou *et al*., 2005) suggested that female have a lower support of autonomic tone necessary to regulate BP as well as a lower effectiveness of the component that regulate the baroreflex. The following conclusion is made: a curvelinear pattern of SBP during 60minutes of recovery was noticed with the decline in SBP crossing the baseline between 3rd and 4th minute and remained persistent below the resting SBP value which is more pronounced in female than male supporting the theory of post-exercise hypotension.

The DBP responses during sixty minutes into the exercise recovery is similar to that obtained in SBP responses in both male and female, in which a curvilinear pattern was also observed. The male subject showed an initial increase from resting DBP of 74.44±1.48mmHg to 82.68±1.70mmHg after ten minutes of exercise representing a positive percentage increase (DBP above resting value) of 11.14%. Following this initial increase at the peak of 10 minutes of exercise, the DBP recorded at 2 minutes into exercise recovery was 4.20% (positive percentage change in respect to resting DBP value). Gradual decline of positive percentage change with time was seen after 2 minutes and at 14th minutes the resting value of DBP reached. The same observation was recorded for the female counterpart, however while at 2 minutes 8.66% positive percentage change recorded, the resting value of DBP was reached at 16th minutes into the exercise recovery. A negative percentage change was thereafter recorded in both sexes and remained negatively persistent to the end of sixty minutes of monitoring (DBP is below resting value), indicating resting value fail to restore with the magnitude not significant, supporting some research work (Sharon and Denise, 2008). Meanwhile, this study also noticed that DBP value in female was at resting level first at 3rd minute into the exercise recovery followed by sudden rebound positive percentage change after 3rd minute, which thereafter returned to resting value at 16th minute. It appears that the sharp drops in DBP in female could be attributed to the phenomenon of female having reduced vasoconstriction and a lower vascular bed resistance in active tissue performing a dynamic aerobic exercise as suggested by a research work especially after exercise (Bassareo and Crisafulli, 2020). Moreover, exhibition of reduced capacity to vasoconstrict the arteriolar bed as compared to men, and the fact that the decrease in blood pressure during recovery after a dynamic effort is greater in females than in males could be attributed to a greater decrease in stroke volume and a lower rise in systemic vascular resistance in women during recovery which usually persist for 5 minutes after the end of exercise (Carter, *et al*., 2001).

Secondly, the lower Systemic Vascular Resistance (SVR) level of women after exercise have been attributed to a possible explanation a) Female sex hormones, by exerting releasing effect on peripheral resistance vessels (Wallin *et al*., 2010) which could be antagonized through myogenic auto regulation that might be probably the cause of high positive percentage change after 3 minutes and b) High sympathetic activity towards the hearts as well as less sympathetic input to the vascular regulation in women than in men (Fisher *et al*., 2013). It is therefore, obvious that DBP response after a dynamic exercise is regulated through vascular tone with female exhibiting a reduced vasoconstriction and a lower vascular resistance in comparison with male.

The resting Heart rate value of female observed in this work was significantly higher compared to the male counterpart, a phenomenon attributed to lower resting vagal tone discharge in female (Girdler *et al*., 1990). It is commonly accepted that during dynamic exercise the cardiovascular system is adjusted through autonomic nervous system which is characterized firstly by vagal withdrawal followed by sympathetic activation (Maciel *et al*., 1986). These two effects accelerate Heart rate to avoid blood pressure drops due to metabolic induced arteriolar vasodilation in the working muscle that could markedly reduce systemic vascular resistance (SVR) as reported by other study (Romero *et al*., 2017). Therefore, increase heart rate recorded at the end of the present study also substantiated the claim. More so, the study records higher positive percentage change in heart rate in female compared to male counterpart indicating that HR in female at end of exercise is still higher than male counterpart, this could also be seen as genetic difference and lower vagal tone in female than in male. The positive percentage change at 2 minutes into the recovery were 16.08% and 19.77% in both male and female respectively, indicating that female still has higher positive percentage change compared to the male. This represent a fast phase of heart recovery from aerobic dynamic exercise which some studies attributed to parasympathetic reactivation (Pecanha *et al*., 2016). The second phase of heart rate recovery in both subjects thought to be due to withdrawal of sympathetic outflow (Seiller *et al*., 2007), showed a gradual positive percentage decline with time with curvilinear pattern. However, while this positive percentage change remained positive till the end of 60 minutes in male, the female heart rate returned to baseline at the end of 40 minutes and remained negative till the end of the 60 minutes, indicating that the heart rate in male remained positive (slightly above resting heart rate value), while female heart rate remained negative (slightly below resting heart rate value). Therefore, it could be seen that heart rate in both male and female failed to return to baseline at the end of 60 minutes.

*60-Minutes post-exercise cardiovascular responses*

In summary, the pattern of reduction in blood pressure following 10 minutes of dynamic aerobic exercise were not different between both sexes. Meanwhile, systolic blood pressure was significantly reduced at 2nd minute and was at baseline at 3rd minute for both sexes. The curve, thereafter was persistently negative to the end of sixty minutes of recovery, the female curve was more negative (faraway from baseline) than the male. A significant reduction of DBP was also recorded at 2 minutes in both sexes, and was at baseline at 14th minute in male and 16th minute in female. However, interestingly the female DBP first attained baseline at 3rd minute then rebound and reached baseline at 16th minute. The result also demonstrated that DBP in both male and female, though below resting value, but were not far from baseline. The heart rate also showed a significant decrease at 2nd minute, followed by a gradual decline, the curve were slightly above the baseline in both male and female. It seemed that SBP is more reliable in determining cardiovascular response to exercise in both male and female.

The pattern of SBP and DBP decrease after 10 minutes of dynamic aerobic exercise is curvelinear, with SBP cross baseline at 3 minutes in both sexes and remained persistent below the baseline, while the DBP cross the baseline at 14th and 16th minute in male and female respectively. The HR showed the same pattern however, the curve remained above the baseline till the end of 60 minutes.

***Recommendation***

*Based on the findings of this research, further study is recommended to compare Heart rate Variability and Blood Pressure in both athletes and Normotensive subjects.*

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