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EFFECT OF AN EXERCISE REGIMEN ON BLOOD PRESSURE IN GRADE 1 HYPERTENSIVE ADULTS

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Purpose: The primary aim of the study was to assess the change in resting Blood Pressure (BP) following a 6 week exercise regimen in grade 1 hypertensive adults. The Secondary aim of the study was to assess the change in Resting Heart Rate (RHR) after a 6 week exercise regimen in grade I hypertensive adults.

Methodology: This study employed an experimental research design because specific conditions were controlled and its effects observed. In this case, exercise was controlled by the researcher and the influences on resting BP and Resting Heart Rate (RHR) observed. A sample of 15 adults was used in this study. Data was analyzed using SPSS version 25 (IBM Limited, UK, 2017) and Microsoft Excel 2013 for Windows. The significance level was set at $p < 0.05$. Data was tested for normal distribution using the Shapiro-Wilk test while the Levenes test was used to test for data normality. Data was determined to be parametric. A paired t-test was used to compare mean differences from baseline, mid-point and post-test within the group

Results: There was no significant difference observed at baseline for mean Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) within the Exercise Group (EX) group ($p > 0.05$). The EX group had a mean SBP and DBP of 142.3 ± 7.4 mmHg and 90.9 ± 3.9 mmHg at baseline. Following an exercise regimen conducted for 45 minutes 5 times a week the SBP and DBP reduced by -2.1 ± 4.2 mmHg and -1.1 ± 4.8 mmHg respectively after 3 weeks and reduced further by -4.6 ± 3.1 mmHg and -3.4 ± 3.9 mmHg after 6 weeks. These changes were not statistically significant ($p > 0.05$) after 3 weeks for SBP and DBP respectively, however they were significant after 6 weeks for both SBP ($p < 0.001$) and DBP ($p < 0.05$). In addition, there was no significant difference observed at baseline for RHR within the EX group ($p > 0.05$). The EX group had a RHR of 76.9 ± 12.6 bpm at baseline. Following an exercise regimen conducted for 45 minutes 5 times a week the RHR reduced by -3.9 ± 4.9 bpm after 3 weeks and reduced further by -6.9 ± 4.9 bpm after 6 weeks. The changes were statistically significant ($p < 0.05$) after 3 weeks and 6 weeks respectively.

Recommendations for further research: Since there is limited and conflicting research on the effects of combined aerobic and resistance training (concurrent training) on BP, future research needs to focus on determining whether it is superior to aerobic or resistance training. Future studies on hypertensive individuals could investigate safe methods of increasing exercise intensities in view of the fact that increased exercise intensities have been shown to increase the amount BP reduction. However individuals with hypertension are restricted to lower intensities.

Key Words: *Blood pressure, exercise regimen, grade 1 hypertensive adults*

1.0 INTRODUCTION

Background of the study

Hypertension affects 20% of the adult population worldwide and is considered to be a multi-factorial disorder of unknown etiologies (Ho, Low & Rose'Meyer, 2016). Hypertension (systolic and diastolic blood pressure $\geq 140/90$ mmHg) has severe social, economic and human consequences particularly in poor populations such as Kenya (WHO, 2014). The WHO global status report on non-communicable diseases (2014) states that the age-adjusted prevalence of raised blood pressure amongst the adult Kenyan population is 21.1% with individuals aged 30 to 70 years having a 15-19% chance of dying from this disease. In the lower middle income countries of Sub-Saharan Africa such as Kenya, the mortality amongst patients being hospitalized for secondary diseases relating to hypertension is over 20% (Twagirumukiza and Van Bortel, 2010), thus if a major cardiovascular risk factor such as hypertension is controlled it may reduce the cardiovascular disease burden for the region.

Regular physical activity/exercise reduces BP and is medically recommended in the control of BP in individuals with hypertension (Pagonas et al., 2013). Studies have shown that exercise as a lifestyle modification is effective in decreasing BP (Cornelissen, Buys & Smart, 2013; Huang et al., 2013; Kiviniemi et al., 2015; Liu, Goodman, Nolan, Lacombe & Thomas, 2012; Pagonas et al., 2013) with acute reductions of 5-20 mmHg after exercise (Kiviniemi et al., 2015) and 7.0 mmHg after chronic (8week) exercise (Liu, Goodman, Nolan, Lacombe & Thomas, 2012). There are various proposed mechanisms for the reduction of BP through exercise such as reduced sympathetic tone (Pagonas et al., 2013) due to decreased nervous system activation (Edwards, Wilson, Sadja, Ziegler & Mills, 2011), decreased arterial stiffness (Kiviniemi et al., 2015) due to favorable vascular remodeling of elastin and collagen content (Liu, Goodman, Nolan, Lacombe & Thomas, 2012), increased vasodilation through an increase in endothelial nitric oxide synthase (eNOS) activity thus increasing nitric oxide (NO) (García-Hermoso, Saavedra & Escalante, 2013) and decreased renin activity which leads to vasodilation and decreased blood volume and consequently reduced BP (García-Hermoso, Saavedra & Escalante, 2013).

Statement of the Problem

Since blood pressure treatment and control is expensive, the prevalence of hypertension within lower-middle income countries (such as Kenya) has increased, consequently increasing the cardiovascular disease burden. Hypertensive individuals do not get appropriate care because they cannot afford the medication and treatment which leads to secondary cardiovascular diseases associated with raised blood pressure. The age-adjusted prevalence of raised blood pressure is 21.1% amongst the Kenyan adult population (WHO, 2014) and is on the rise (M'Buyamba-Kabangu et al., 2013). Since hypertension is a major risk factor and driving force for cardiovascular diseases, finding an economical and accessible method of controlling it may reduce the cardiovascular disease burden in Kenya.

Purpose of the Study

The primary aim of the study was to assess the change in resting Blood Pressure (BP) following a 6 week exercise regimen in grade 1 hypertensive adults. The Secondary aim of the study was to assess the change in Resting Heart Rate (RHR) after a 6 week exercise regimen in grade I hypertensive adults.

Hypothesis

H₀₁ . There is no significant difference in the changes observed in resting Blood Pressure (BP) in adults with grade I hypertension following a 6 week exercise regimen.

H₀₂ . There is no significant difference in the changes observed in Resting Heart Rate (RHR) in adults with grade I hypertension following a 6 week exercise regimen.

2.0 LITERATURE REVIEW

Physical Exercise and Blood Pressure

Exercise training has been shown to reduce sympathetic activation and increase the parasympathetic nervous system activity in both normotensive and hypertensive individuals. Although this mechanism is not yet fully understood, the roles of oxidative stress, the renin-angiotensin-aldosterone system and inflammation have been suggested (Edwards, Wilson, Sadja, Ziegler & Mills, 2011). This anti-hypertensive mechanism due to exercise is to a degree similar to the effects of a beta blocker. A study by Martinez *et al.* (2011) investigated the effect of long term exercise training on autonomic control in myocardial infarction patients where one of their objectives was looking at muscle sympathetic nerve activity (MSNA) after long term exercise. The study concluded that long term exercise training significantly reduced MSNA and consequently the systolic arterial pressure (SAP), thus showing marked improvements in autonomic control.

Exercise has also been shown to decrease arterial stiffness after acute and chronic exercise thereby reducing peripheral resistance (Kiviniemi *et al.*, 2015). A study by Tanaka *et al.* 2000 studied the central arterial compliance (simultaneous B-mode ultrasound and arterial applanation tonometry on the common carotid artery) of 151 healthy middle-aged men to determine the role of habitual exercise on age related changes on arterial compliance. The study showed that regular endurance exercise intervention caused a considerable increase in arterial compliance thus reducing the arterial stiffness brought about due to age related changes. Another study by Tabara *et al.* (2007) was not able to observe any changes in arterial stiffness following acute exercise, however, a large reduction (-7/5 mmHg) was observed after 6 months of exercise training among elderly individuals. In the study, there was a direct correlation between radial arterial augmentation index (AI) and BP following chronic exercise. The AI reduced from 87% to 84% while the BP reduction was -7/5 mmHg. Arterial stiffness was also shown to reduce due to a favorable vascular remodeling of elastin and collagen content due to exercise (Liu, Goodman, Nolan, Lacombe & Thomas, 2012).

Exercise has also been shown to reduce BP by increasing endothelial nitric oxide synthase (eNOS) activity and expression (García-Hermoso, Saavedra & Escalante, 2013). An increase in eNOS will increase nitric oxide (NO), which will induce vasodilation, while reducing peripheral resistance and thus reduce BP. Data suggests that exercise training can increase NO bioavailability in individuals with established disease or at risk of cardiovascular disease and may be an important mechanism in secondary prevention of disease (Kingwell, 2000).

According to the ACSM position stands (2004) exercise remains a cornerstone therapy for the primary prevention, treatment, and control of hypertension. Studies have shown that exercise is beneficial in reducing BP in individuals with hypertension (Bento *et al.*, 2015; Edwards, Wilson,

Sadja, Ziegler & Mills, 2011; Liu, Goodman, Nolan, Lacombe & Thomas, 2012; Lo, Yeh, Chang, Sung & Smith, 2012; Pagonas et al., 2013). Physical inactivity seems to play a role in increasing BP and deterioration of blood vessels in both hypertensive and normotensive individuals (Huang et al., 2013).

Blood Pressure can be lowered transiently after acute exercise (one exercise session), and this effect is often termed post exercise hypotension (PEH), and the degree of this change has been related to the magnitude of change in BP observed after chronic exercise (Liu, Goodman, Nolan, Lacombe and Thomas, 2012). This reduction in BP brought about due to acute and chronic exercise has been shown to be particularly pronounced in individuals with hypertension (Millar & Goodman, 2014). A study by Liu, Goodman, Nolan, Lacombe and Thomas (2012) looked at the BP response to acute and chronic exercise in 17 pre-hypertensive males and females (45–60 years old) who were not on any antihypertensive medication, showed that BP was significantly reduced by 7.2/4.2 mmHg following acute exercise and by 7.0/5.2 following chronic exercise. The study indicated that the magnitude of change in BP after acute exercise was strongly correlated with change after chronic exercise, thus showing the importance of the transient reduction in blood pressure following exercise, in the maintenance of long term (chronic) blood pressure control.

Although numerous studies have shown that aerobic endurance exercise is an effective method of reducing BP in individuals with hypertension (Huang et al., 2013; Liu, Goodman, Nolan, Lacombe and Thomas, 2012; Pagonas et al., 2013), a study by (Paoli et al., 2013) showed that a 12 week high intensity circuit (HICT) training and low intensity circuit training was more effective in improving BP than traditional endurance training (ET). The HICT and LICT training group had reductions of -7/6 mmHg and -11/-2 mmHg respectively as compared to the ET group which had reductions of -5/3 mmHg. SBP reduction was highest in the LICT group while DBP was highest in the HICT, showing that a combination of both high and low intensities in the workout are beneficial in lowering average BP.

Since majority of the previous studies have focused mostly on endurance training as their primary exercise modality, this study focused on using a combination of both endurance and resistance training because it has been shown to be more effective than using endurance training alone in reducing BP. Exercise intensities were maintained at $40 \leq 60$ VO₂max as per present guidelines by the American College of Sports Medicine (Pescatello et al., 2004; Pescatello, MacDonald, Lamberti & Johnson, 2015) for blood pressure reduction for people with hypertension.

Exercises and Heart Rate

Studies have shown that an increase in cardiorespiratory fitness or exercise participation causes a decrease in RHR and increased myocardial efficiency (Fløtum, Ottesen, Krstrup & Mohr, 2016; Park et al., 2018; Schroeder, Welk, Franke & Lee, 2017; Silva, Lima & Tremblay, 2018). Three mechanisms have been proposed for this reduction in RHR which include, improvements in cardiorespiratory fitness that causes an increase in left ventricular thickness/diameter and increased systolic volume (due to decreased peripheral resistance and increased plasma volume) which finally leads to an increase in stroke volume. This increase in stroke volume leads a decrease in the number of beats required to maintain resting cardiac output. This decreases the metabolic load of the heart thus causing a decrease in resting heart rate (Bellenger et al., 2016; da

Silva et al., 2013; Snoek, van Berkel, van Meeteren, Backx & Daanen, 2013). Secondly, high levels of aerobic fitness causes an increase in parasympathetic nervous activity while reducing sympathetic nervous system activity, thus increasing vagal tone and reducing RHR. (da Silva et al., 2013). Thirdly, imbalance of tonic activity of the sympathetic accelerator and parasympathetic depressor neurons due to increased cardio-metabolic demands of training accompanied with counter-resistance effort in favor of vagal tone. This results in a decrease in RHR (Silva, Lima & Tremblay, 2018)

A study by Schroeder, Welk, Franke and Lee (2017), investigated the association of health club membership with physical activity and HR (n=204 club members and n=201 non-members; age 30-64 years). The subjects completed a PA questionnaire about both resistance and aerobic training activities at the health club based on the International Physical activity questionnaire (IPAQ). 87% and 84% of individuals with health club memberships were able to achieve the physical activity guidelines recommendations (PAG) of at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity per week while those without membership achieved 30% and 36%. Results showed that the individuals with health club memberships had a higher cardiorespiratory fitness and had a lower RHR (67 bpm) as compared to those without a membership (71 bpm). The odds-ratio of cardiovascular health outcome of health club members were lower for elevated RHR after adjusting for confounding factors. This study shows the relationship between higher cardiorespiratory fitness or exercise participation and lower RHR.

A study by Silva, Lima and Tremblay (2018) identified the relationship between physical fitness components (Muscle strength, Flexibility, aerobic fitness and body fat) and RHR in Brazilian adolescents (n=695 and age=14-19 years). The study concluded there was a direct correlation between higher aerobic fitness (boys and girls) and muscular strength (boys) with reduction in RHR. There was a strong association between lower body fat percentages and lower RHR, however did not find any association between flexibility and RHR values. The age group was limited to 14-19 years which was outside the scope of the present study, however the results were similar to the study by Schroeder, Welk, Franke and Lee (2017) where the study population was 30-64 years which is a similar age group to the present study. In the study by Silva, Lima & Tremblay (2018) physical activity was determined by a question from Youth Risk Behavior Surveillance Questionnaire which did not determine duration and type of exercise (aerobic or resistance) that has been undertaken. However they were able to determine that developing both types of physical fitness (cardiorespiratory and muscular strength), was associated with lower RHR, which is what the present study included in the exercises program. The studies above however only looked at the relationships and no interventions were provided.

An exercise intervention study was by Fløtum, Ottesen, Krstrup and Mohr (2016) on 741 adults aged 20-72 years who were recruited for Football fitness training. The subjects trained for 18 week, 2-4 sessions a week for 1 hour per session. There was a reduction of 8% (-6 bpm) in RHR after the 18 week intervention which was suggestive of lowered sympathetic activity, brought about by exercise and was similar for both hypertensive and normotensive individuals. The RHR was lowered irrespective of age group, pre-intervention MAP and the recovery HR at 1,2, and 3 minutes of Yo-Yo running test was reduced, which suggest lowered sympathetic activity at rest and at elevated stroke volume during exercise. The results were similar to a study by Mathunjwa

Stuart and Du Preez (2013) on 67 obese but healthy (mean age of 25) African female students where the reduction in RHR was -7.5 bpm after a 10 week aerobic exercise program.

3.0 RESEARCH METHODOLOGY

This study employed an experimental research design because specific conditions were controlled and its effects observed. In this case, exercise was controlled by the researcher and the influences on resting BP and Resting Heart Rate (RHR) observed. A sample of 15 adults was used in this study. Data was analyzed using SPSS version 25 (IBM Limited, UK, 2017) and Microsoft Excel 2013 for Windows. The significance level was set at $p < 0.05$. Data was tested for normal distribution using the Shapiro-Wilk test while the Levenes test was used to test for data normality. Data was determined to be parametric. A paired t-test was used to compare mean differences from baseline, mid-point and post-test within the group.

4.0 FINDINGS

4.1 Blood Pressure Response to Exercises

Changes in BP (SBP and DBP) after a 6 week exercise program are presented below in Figure 1.

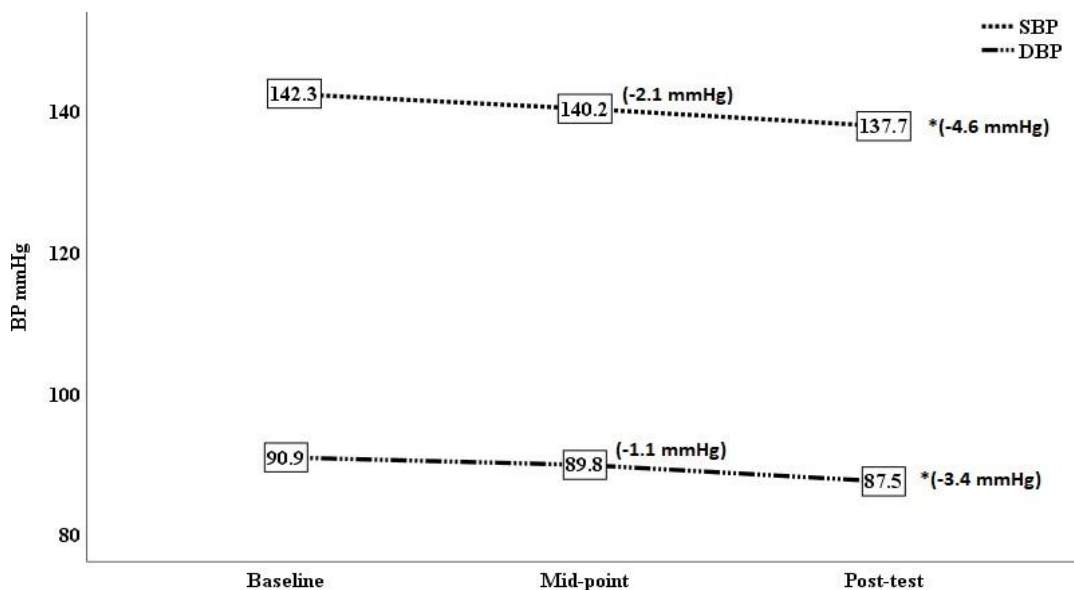


Figure 1: BP changes after 6 weeks of exercise in adults with grade 1 hypertension

There was no significant difference observed at baseline for mean SBP and DBP within the EX group ($p>0.05$). The EX group had a mean SBP and DBP of 142.3 ± 7.4 mmHg and 90.9 ± 3.9 mmHg at baseline. Following an exercise regimen conducted for 45 minutes 5 times a week the mean SBP and DBP reduced by -2.1 ± 4.2 mmHg and -1.1 ± 4.8 mmHg respectively after 3 weeks and reduced further by -4.6 ± 3.1 mmHg and -3.4 ± 3.9 mmHg after 6 weeks. These changes were not statistically significant ($p>0.05$) after 3 weeks for SBP and DBP respectively, however they were significant after 6 weeks for both SBP ($p<0.001$) and DBP ($p<0.05$). Therefore the study rejected the null hypothesis because there was a statistically significant ($p<0.05$) reduction in resting BP (SBP and DBP) following a 6 week exercise regimen in adults with grade 1 hypertension.

4.2 Heart Rate Response to Exercises

Changes in RHR after a 6 week exercise program are presented below in Figure 2.

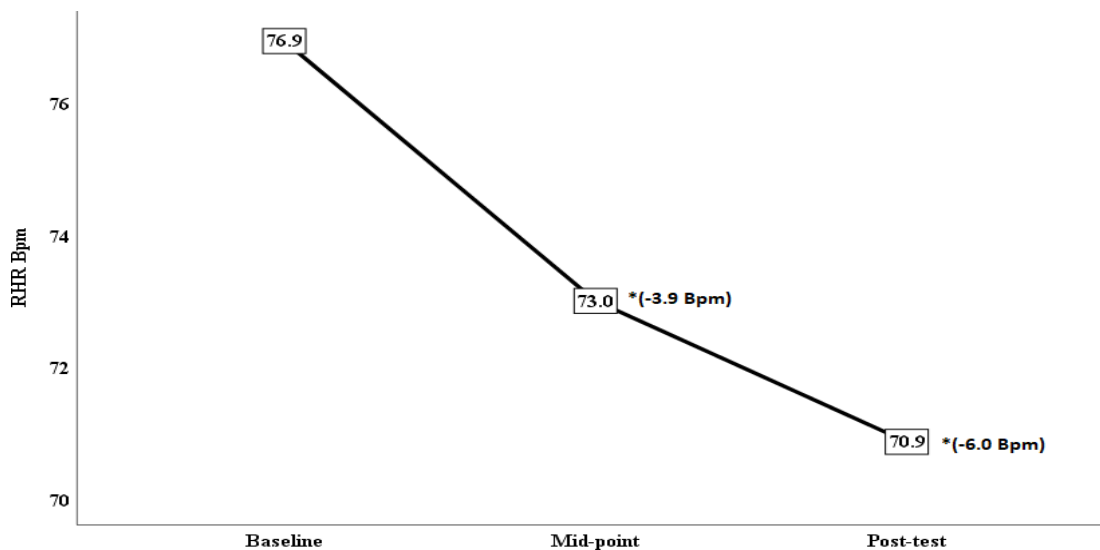


Figure 2: RHR changes after 6 weeks of exercise in adults with grade 1 hypertension.

There was no significant difference observed at baseline for RHR within the EX group ($p>0.05$). The EX group has a RHR of 76.9 ± 12.6 bpm at baseline. Following an exercise regimen conducted for 45 minutes 5 times a week the RHR reduced by -3.9 ± 4.9 bpm after 3 weeks and reduced further by -6.9 ± 4.9 bpm after 6 weeks. The changes were statistically significant ($p<0.05$) after 3 weeks and 6 weeks respectively. Therefore the study rejected the null hypothesis because there was a statistically significant ($p<0.05$) reduction in resting RHR following a 6 week exercise regimen in adults with grade 1 hypertension.

5.0 Discussion of Findings

Blood Pressure Response to Exercise

The present study found significant ($p<0.05$) reductions of -4.6 mmHg and -3.4 mmHg in SBP and DBP respectively in the EX group after 6 weeks (figure 2). These results are similar to two

systematic reviews (Cornelissen and Smart, (2013); Pescatello, MacDonald, Lamberti and Johnson (2015) on the effects of exercise and blood pressure.

The study by Pescatello, MacDonald, Lamberti and Johnson (2015) involved human trials (≥ 19 years), published between 2004 and 2015 (7 meta-analysis and 63 exercise trials) while the study by Cornelissen and Smart (2013) was on RCT's lasting more than 4 weeks on BP in healthy adults (≥ 18 years) up to 2012 (93 trials). The studies above suggested that exercise lowers blood pressure by 3.5-11 mmHg and 2.5-6 mmHg for SBP and DBP respectively. However they noted that the reduction in BP was influenced by the frequency, intensity, time and type of exercise.

The reviews, meta-analysis, and trials were used to update the ASCM (2004) prescription for exercise and hypertension (Pescatello, MacDonald, Lamberti & Johnson, 2015). The updated prescriptions suggest that aerobic exercise should be performed all days of the week and dynamic resistance exercise on 2-3 days in the same week at $40 \leq 60\%$ of VO_2 max or 60-80% one repetition max (1RM) for aerobic and resistance exercise respectively. Aerobic exercise should be performed 30 to 60 minutes per day while resistance training should consist of two to three sets of 10 to 12 repetitions for 8 to 10 exercises. The present study was governed by the prescriptions above. However, even though all the above prescriptions have merit in terms of blood pressure reduction, the combination of aerobic and dynamic exercise (like in the present study) in one program (concurrent exercise program) has weak and limited literature and warrants further investigation even though it has been prescribed within the guidelines.

A study by Paoli et al. (2013) investigated whether a concurrent exercise program is more effective than an aerobic exercise program in reducing BP. The study was conducted on 58 healthy untrained men (50-70 years), placed in either a high intensity circuit training group (HICT), low intensity circuit training group (LICT) and tradition endurance exercise group (ET). The HICT and LICT were both concurrent programs. Results showed that a 12 week high intensity circuit (HICT) training and low intensity circuit training (LICT) is more effective in improving BP than traditional endurance training (ET). The HICT and LICT training groups had reductions of -7/6 mmHg and -11/-2 mmHg respectively as compared to the ET group which had reductions of -5/3 mmHg. The LICT group that were exercising within the same intensity as the present study (50% HRR) had a higher reduction in SBP (6.4 mmHg higher) and lower reduction in DBP (1.4 mmHg lower) than the current study.

The higher reduction in SBP may have been due to the fact that the study duration was twice as long (12 weeks) as the present study thus eliciting higher reductions. The DBP reductions in the study by Paoli et al. (2013) may have been lower because even though they were exercising within the same intensities as the present study, the individuals were limited and could not exert themselves past 50 % HRR while the subjects in the present study were able to go above 50% HRR to 60% VO_2 max. Studies suggest that the effect of exercise on DBP is greatest at high intensity exercise and minimal at low intensity exercises (Paoli et al., 2013), thus individuals should exercise at higher intensities so as to be able to gain significant reductions in DBP.

A study by Liu, Goodman, Nolan, Lacombe and Thomas (2012) on 17 pre-hypertensive males and females (45-60 years) investigated whether the magnitude of BP reduced after acute exercise determined the magnitude of BP reduction in chronic exercise. The results from this study found

a direct correlation between acute BP reductions and chronic BP reductions, thus suggesting that the magnitude of change in BP in acute exercise may predict the magnitude to which BP is lowered after chronic exercise. However in the present study acute BP measurements were not taken. However blood pressure changes were taken at 3 weeks and the reductions (-2.1/1.1 mmHg) were not significant ($p>0.05$). The findings from the present study suggest that the cumulative effect of acute blood pressure changes or PEH did not affect the chronic resting blood pressure by 3 weeks. This finding are similar to that of Liu, Goodman, Nolan, Lacombe and Thomas (2012) where earlier trends of reduction in BP were seen at week 1 (-1.0/1.1 mmHg) and week 3 (-2.0/2/2 mmHg), however the BP reductions did not become statistically significant ($p<0.05$) until week 5. This suggests that even though transient reductions in BP following exercise may affect long term resting blood pressure, it may takes some time for the chronic effect to take place. The implication of this finding is that individuals with hypertension should perform exercise over a longer period of time before they can start seeing the chronic/long term benefits of lowered blood pressure through exercise even after the effects of PEH have disappeared.

Heart Rate Response to Exercise

The present study found a significant ($p<0.05$) reduction in RHR (-6.0 bpm) in the EX group after 6 weeks. The results are similar to a study by Fløtum, Ottesen, Krstrup and Mohr (2016) investigating the heart rate response to exercise on 741 adults (20-72 years) who were recruited for Football fitness training. The subjects trained for 18 weeks, 2-4 sessions a week for 1 hour per session. There was a reduction of 8% (-6 bpm) in RHR after the 18 week intervention irrespective of age. The study was conducted on both hypertensive and normotensive individuals and found that there was a reduction of -5bpm for the hypertensive individuals and -6bpm for the normotensive individuals, which is suggests that the RHR response to exercise is similar regardless of blood pressure status. The difference between the study by Fløtum, Ottesen, Krstrup and Mohr (2016) and the present study was that there was no limitation in exercise intensity and individuals were exercising at high exercise intensities (≥ 70 VO₂ max), while in the present study individuals were restricted to 40-60% of VO₂max. This suggests that higher exercise intensities do not cause a higher reduction in RHR, however when we look at the exercise adherence levels from the study by Fløtum, Ottesen, Krstrup and Mohr (2016), it ranged from 0.6-2.9 sessions a week. This is half the number of sessions as compared to the present study (4 sessions a week). The study concluded that several markers of health profiles can be improved by low volume exercise training if intensity is high enough. This suggest that the number of session per week and training hours do not have to be too large (almost every day as suggested by ACSM, 2004) to elicit the cardiovascular benefits (such as reduced RHR) given that the training intensity is high.

A study by Mathunjwa, Semple, and du Preez, (2016) on 67 obese but healthy women (mean age of 25) yielded similar results to the present study and the study by Fløtum, Ottesen, Krstrup and Mohr (2016) where there was a mean reduction of -7 bpm at the end of the study. The exercise program entailed a Tae-bo session which lasted 1 hour a day and was done 3 times a week. The intensity was moderate (11-13 RPE) for the first five weeks and proceeded to high intensity (14-16 RPE) during the remaining 5 weeks. There were similar reductions in RHR at midpoint (-3.8

bpm) and posttest (-3.7bpm) which suggests that the increase in intensity did not cause and higher reduction in RHR. The difference between the present study and the study by Mathunjwa, Semple, and du Preez, (2016) is that the exercise program in the present study was a mixture of resistance and aerobic exercise (concurrent exercise program) while in the study by Mathunjwa, Semple, and du Preez, (2016) was primarily aerobic in nature. It would be difficult to draw conclusions from the results of both studies because the duration of the exercise program was not the same and the intensities were not the same.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study concluded that exercise (45 min, 5 times a week) is an effective method of reducing RHR in individuals with hypertension after 6 weeks. Therefore the study rejects the null hypothesis because there was a statistically significant ($p < 0.05$) reduction in resting RHR following a 6 week exercise regimen in adults with grade 1 hypertension.

Recommendations

Since this study was only undertaken over a short period of time (6 weeks) with a small sample size ($n=15$) future studies should focus on having the investigation done over a longer period of time with a larger sample size. This is due to the fact that it does not take the same time for changes in BP to occur when exercising.

Since there is limited and conflicting research on the effects of combined aerobic and resistance training (concurrent training) on BP, future research needs to focus on determining whether it is superior to aerobic or resistance training.

Future studies on hypertensive individuals should investigate safe methods of increasing exercise intensities. This is due to the fact that increased exercise intensities have been shown to increase the amount BP reduction. However individuals with hypertension are restricted to lower intensities.

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