EFFECT OF EXERCISE AND MAGNESIUM ON BLOOD PRESSURE AND HEART RATE IN HYPERTENSIVE ADULTS IN NAIROBI AND KIAMBU COUNTIES, KENYA

EDWIN KIPTOLO BOIT (MSc)
H87/32697/2015

A RESEARCH THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN EXERCISE AND SPORT SCIENCE, SCHOOL OF PUBLIC HEALTH AND APPLIED HUMAN SCIENCES, KENYATTA UNIVERSITY.

MAY 2019
STUDENT'S DECLARATION

This thesis is my original work and has not been presented for any award in any other university.

Signature______________________ Date __________________

Edwin Kiptolo Boit - H87/32697/2015

Supervisors:

This thesis has been submitted for review with our approval as university supervisors:

1. Signature______________________ Date __________________

Gitahi Theuri, PhD
Department: Recreation Management and Exercise Science
Kenyatta University

2. Signature______________________ Date______________________

Dr. Gordon Ogweno, PhD
Department: Medical Physiology
Kenyatta University
DEDICATION STATEMENT

I dedicate this work to my parents, James Boit and Catherine Boit who have constantly supported me emotionally and financially through the challenges of doctoral work.
ACKNOWLEDGMENT

First and foremost, I would like to appreciate the consistent support of my two supervisors, Dr. Gitahi Theuri and Dr. Gordon Ogweno during my doctoral work. Their motivation, knowledge and insights are what have allowed me to complete my thesis. I would also like to thank Caroline Mwangi and Angelina Njoroge, the two nurses who assisted me in accurately measuring blood pressure and resting heart rates during the pretests and post-tests. In addition, my heartfelt gratitude to Nicholas Mwangi and Gaudencia Sichangi, my research assistants who assisted me in recruiting subjects, conducting the exercise programs, dispensing the magnesium supplements amongst other responsibilities. I cannot forget to thank Ellyjoy Nyagah for assisting me at the Human Performance Lab. In addition, I would like to thank Dr. Maxwell Maina for facilitating my study at the Thika Level 5 Hospital and my friends and colleagues at Kenyatta University for advising me when in doubt. Lastly, I would like to thank my immediate and extended family for supporting me emotionally through the data collection and thesis writing.
TABLE OF CONTENTS

STUDENT’S DECLARATION ........................................................................................................ii
DEDICATION STATEMENT ......................................................................................................iii
ACKNOWLEDGMENT ..............................................................................................................iv
TABLE OF CONTENTS ..........................................................................................................v
LIST OF TABLES ..................................................................................................................x
LIST OF FIGURES .................................................................................................................xi
ABBREVIATIONS AND ACRONYMS ..................................................................................xii
DEFINITION OF TERMS ........................................................................................................xiv
OPERATIONAL DEFINITIONS OF TERMS ............................................................................xv
ABSTRACT ..............................................................................................................................xvi

CHAPTER ONE: INTRODUCTION ......................................................................................... 1
1.1 Background to the Study ................................................................................................. 1
1.2 Statement of the Problem .............................................................................................. 4
1.3 Purpose of the Study .................................................................................................... 5
1.4 Objectives of the Study .................................................................................................. 5
1.5 Hypothesis ..................................................................................................................... 7
1.6 Significance of the Study ............................................................................................. 8
1.7 Delimitations of the Study ............................................................................................ 8
1.8 Limitations of the Study ............................................................................................ 9
1.9 Assumptions of the Study ........................................................................................... 9
1.10 Conceptual Framework ...............................................................................................10

CHAPTER TWO: LITERATURE REVIEW ............................................................................. 12
2.1 High Blood Pressure ..................................................................................................... 12
CHAPTER THREE: METHODOLOGY ................................................................. 30
3.1 Research Design .................................................................................. 30
3.2 Measurements of Variables .................................................................. 30
3.2.1 Independent Variables .................................................................... 30
3.2.2 Dependent Variables ..................................................................... 30
3.3 Study Location .................................................................................... 31
3.4 Target Population ................................................................................ 31
3.5 Inclusion Criteria ................................................................................ 32
3.6 Exclusion Criteria .............................................................................. 32
3.7 Sample Size and Sampling Technique ............................................... 33
3.8 Research Instruments ........................................................................ 34
3.8.1 Mercury Sphygmomanometer (Rudolf Reister GmbH, Bruckstr, Jungingen, Germany) ...................................................................................................................... 34
3.8.2 Heart Rate Monitor (Garmin, Olathe, Kansas, US) ...................... 34
3.8.3 Suhong RGZ-120 Stadiometer (Jiangsu Suhong Medical Instruments Co., China) .................................................................................................................. 34
3.8.4 Magnesium Citrate Supplement (Now, Bloomingdale, IL, US) ....... 35
3.8.5 Exercise Program ......................................................................... 35
CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS .................. 45
4.1 Introduction ............................................................................. 45
4.2 Participants Characteristics and Anthropometrics .................. 46
4.3 Blood Pressure Response ....................................................... 47
4.3.1 Blood Pressure Response to Exercise ............................. 47
4.3.2 Blood Pressure Response to Magnesium ......................... 49
4.3.3 Blood Pressure Response to Combined Exercise and Magnesium .... 50
4.3.4 Comparison of Blood Pressure Responses between the 3 Groups .... 51
4.4 Relationship between Resting Heart Rate and Blood Pressure .... 53
4.5 Heart Rate Response .......................................................... 55
4.5.1 Heart Rate Response to Exercise ..................................... 55
4.5.2 Heart Rate Response to Magnesium .............................. 56
4.5.3 Heart Rate Response to Combined Exercise and Magnesium .... 57
4.5.4 Comparison of Heart Rate Responses between the 3 Groups .... 58
CHAPTER FIVE: DISCUSSION OF FINDINGS ........................................ 61
5.1 Introduction .............................................................................. 61
5.2 Blood Pressure Response ....................................................... 61
  5.2.1 Blood Pressure Response to Exercise .............................. 61
  5.2.2 Blood Pressure Response to Magnesium Supplementation .. 64
  5.2.3 Blood Pressure Response to Combined Exercise and Magnesium .. 66
  5.2.4 Comparison of Blood Pressure Response between the 3 groups . 68
5.3 Relationship between Resting Heart Rate and High Blood Pressure .... 71
5.4 Heart Rate Response ................................................................ 72
  5.4.1 Heart Rate Response to Exercise ..................................... 72
  5.4.2 Heart Rate Response to Magnesium ................................. 74
  5.4.3 Heart Rate Response to combined Exercise and Magnesium .. 74
  5.4.4 Comparison of Resting Heart Rate Response between the 3 groups . 75

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS ... 77
6.1 Summary ............................................................................... 77
6.2 Conclusion ............................................................................. 78
6.3 Recommendations ............................................................... 80
  6.3.1 Practice and Policy ......................................................... 80
  6.3.2 Further Research ........................................................... 81

REFERENCES ............................................................................... 82

APPENDICES .............................................................................. 91
APPENDIX A.1: INFORMED CONSENT FORM (ENGLISH) .............. 91
APPENDIX A.2: FOMU YA RIDHAA (KISWAHILI) ............................. 93
LIST OF TABLES

Table 2.1 Hypertension Classification (WHO 2018).................................................. 12

Table 4.1: Groups’ characteristics and anthropometrics before and after 6 weeks of exercise, magnesium or combination of exercise and magnesium. .......................... 46
LIST OF FIGURES

Figure 1.1 Conceptual framework on the combined effect of exercise and magnesium on blood pressure .............................................................................................................. 10

Figure 4.1 BP changes after 6 weeks of exercise in adults with grade 1 hypertension ......................................................................................................................... 48

Figure 4.2 BP changes after 6 weeks of magnesium supplementation in adults with grade 1 hypertension. ...................................................................................... 49

Figure 4.3 BP changes after 6 weeks of combined exercise and magnesium supplementation in adults with grade 1 hypertension. ........................................ 50

Figure 4.4 SBP changes after 6 weeks of exercise, magnesium or combination of exercise and magnesium in adults with grade 1 hypertension ...................... 51

Figure 4.5 DBP changes after 6 weeks of exercise, magnesium or combination of exercise and magnesium in adults with grade 1 hypertension ...................... 53

Figure 4.7 Changes in DBP vs. changes in RHR after 6 weeks of exercise, magnesium or combination of exercise and magnesium ........................................ 54

Figure 4.8 RHR changes after 6 weeks of exercise in adults with grade 1 hypertension ...................................................................................................................... 56

Figure 4.9 RHR changes after 6 weeks of magnesium supplementation in adults with grade 1 hypertension .................................................................................. 57

Figure 4.10 RHR changes after 6 weeks of combined exercise and magnesium in adults with grade 1 hypertension ............................................................................. 58

Figure 4.11: RHR changes after 6 weeks of exercise, magnesium supplementation or combination of exercise and magnesium supplementation in adults with grade 1 hypertension ................................................................. 59

Figure 8.1: Graphical depiction of the outdoor circuit training program ............... 101
### ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1RM</td>
<td>1 Repetition Maximum</td>
</tr>
<tr>
<td>ACSM</td>
<td>American College of Sports Medicine</td>
</tr>
<tr>
<td>Al</td>
<td>Augmentation Index</td>
</tr>
<tr>
<td>ANS</td>
<td>Autonomic Nervous System</td>
</tr>
<tr>
<td>BP</td>
<td>Blood Pressure</td>
</tr>
<tr>
<td>BPM</td>
<td>Beats Per Minute</td>
</tr>
<tr>
<td>CO</td>
<td>Cardiac Output</td>
</tr>
<tr>
<td>DBP</td>
<td>Diastolic Blood Pressure</td>
</tr>
<tr>
<td>EMG</td>
<td>Exercise and Magnesium Supplementation Group</td>
</tr>
<tr>
<td>eNOS</td>
<td>Endothelial Nitric Oxide</td>
</tr>
<tr>
<td>ET</td>
<td>Traditional Endurance Training</td>
</tr>
<tr>
<td>EX</td>
<td>Exercise Group</td>
</tr>
<tr>
<td>HICT</td>
<td>High Intensity Circuit Training</td>
</tr>
<tr>
<td>HR</td>
<td>Heart Rate</td>
</tr>
<tr>
<td>HRR</td>
<td>Heart Rate Reserve</td>
</tr>
<tr>
<td>IPAQ</td>
<td>International Physical Activity Questionnaire</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
</tr>
<tr>
<td>KU-ERC</td>
<td>Kenyatta University Ethical Review Committee</td>
</tr>
<tr>
<td>LVEF</td>
<td>Left Ventricular Ejection Fraction</td>
</tr>
<tr>
<td>LVDD</td>
<td>Left Ventricular Diastolic Dysfunction</td>
</tr>
<tr>
<td>LVSD</td>
<td>Left Ventricular Systolic Dysfunction</td>
</tr>
<tr>
<td>LICT</td>
<td>Low Intensity Circuit Training</td>
</tr>
<tr>
<td>MG</td>
<td>Magnesium</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>MSG</td>
<td>Magnesium Supplementation Group</td>
</tr>
<tr>
<td>MSNA</td>
<td>Muscle Sympathetic Nerve Activity</td>
</tr>
<tr>
<td>Na</td>
<td>Sodium</td>
</tr>
<tr>
<td>NACOSTI</td>
<td>National Commission for Science, Technology and Innovation</td>
</tr>
<tr>
<td>NCD</td>
<td>Non Communicable Disease</td>
</tr>
<tr>
<td>NO</td>
<td>Nitric Oxide</td>
</tr>
<tr>
<td>NOS</td>
<td>Nitric Oxide Synthase</td>
</tr>
<tr>
<td>PAD</td>
<td>Peripheral Artery Disease</td>
</tr>
<tr>
<td>PAG</td>
<td>Physical Activity Guidelines</td>
</tr>
<tr>
<td>PEH</td>
<td>Post Exercise Hypotension</td>
</tr>
<tr>
<td>PGE1</td>
<td>Prostaglandin E1</td>
</tr>
<tr>
<td>PNS</td>
<td>Parasympathetic Nervous System</td>
</tr>
<tr>
<td>RHR</td>
<td>Resting Heart Rate</td>
</tr>
<tr>
<td>RTC’s</td>
<td>Randomized Controlled Trials</td>
</tr>
<tr>
<td>SAP</td>
<td>Systolic Arterial Pressure</td>
</tr>
<tr>
<td>SBP</td>
<td>Systolic Blood Pressure</td>
</tr>
<tr>
<td>TPR</td>
<td>Total Peripheral Resistance</td>
</tr>
<tr>
<td>VO₂</td>
<td>Maximum Oxygen Consumption</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
DEFINITION OF TERMS

**Cardiovascular Diseases**: all diseases that affect the blood or heart.

**Circuit Training**: training that can be organized into a circuit with a series of workstations. An individual moves from one station to the next after a specific time allocation.

**Concurrent Training**: a combination of aerobic and resistance training in one session.

**Resting Blood Pressure**: the pressure exerted on arterial walls measured in mmHg when you are completely at rest.

**Resting Heart Rate**: the number of times the heart beats when an individual is completely at rest.

**Sub Saharan Africa**: all African countries located partially or fully south of the Sahara Desert.
OPERATIONAL DEFINITIONS OF TERMS

**Acute Exercise**: one bout of exercise.

**Acute Blood Pressure**: blood pressure measurements taken immediately after exercise.

**Adults**: individuals between the ages of 30 and 60 years.

**Chronic Blood Pressure**: blood pressure measurements taken after a 6 week exercise program.

**Chronic Exercise**: exercise that is undertaken over a duration of 6 weeks.

**Grade I Hypertension**: systolic blood pressure between 140-159 mmHg and diastolic blood pressure between 90-99 mmHg.

**High Intensity Circuit Training**: a combination of aerobic and resistance exercises that are organized into a circuit with a series of workstations where VO2 is maintained at or greater than 75%.

**Kiambu County**: Thika Level 5 hospital where subjects were recruited and is located within Kiambu County.

**Low Intensity Circuit Training**: a combination of aerobic and resistance exercises that are organized into a circuit with a series of workstations where heart rate reserve is maintained at or below 50%.

**Magnesium Supplementation**: 500mg daily dosage of magnesium citrate supplements.

**Nairobi County**: Kenyatta University where subjects were recruited and is located within Nairobi County.

**Traditional Endurance Training**: a training program that includes only aerobic exercises that are done at low intensity.
ABSTRACT

Physical exercise and magnesium have both been shown to independently cause reductions in blood pressure (BP). The primary objective of this study was to investigate the combined effect of exercise and magnesium on blood pressure. The secondary objective was to investigate the effects on resting heart rate (RHR) over a 6 week period. Forty seven (47) hypertensive adults (25 males and 22 females) who were recruited from Kenyatta University and Thika Level 5 hospital, were randomly assigned to an exercise only group (EX; n=15), magnesium only group (MGS; n=18), and a combination of exercise and magnesium (EMG, n=14). The EX and EMG group performed moderate intensity circuit training (40≥60 VO₂max) for 45 minutes, 5 times a week, with intensities being monitored using a heart rate monitor (Garmin, Olathe, Kansas, US). The EMG group also took magnesium citrate supplements (Now, Bloomingdale, IL, US) (500 mg/day) concurrently with the MGS group. This was a pretest-posttest experimental study where Brachial BP (using a Mercury Sphygmomanometer: Rudolf Reister GmbH, Bruckstr, Jungingen, Germany), RHR, and anthropometric measurements (Height, weight, hip circumference and waist circumference) were taken at baseline, mid-point and post-test. Data were analyzed using SPSS version 25 and Microsoft Excel 2013 for Windows. The significance levels were set at p<0.05. Data were tested for normal distribution using the Shapiro-Wilk test while the Levenes test were used to test for data normality, which classified all the data as parametric. A paired t-test was used to compare mean differences within the groups, while a two-way ANOVA were used to compare mean differences from baseline, mid-point and post-test between the groups. If the differences between pretest and posttest were statistically significant, the Bonferroni post-hoc test was used for pairwise comparisons. A linear regression analysis was used to determine the relationship between BP and RHR. The EMG group had the largest reduction in SBP (-7.1 ± 2.2 mmHg, p<0.001) followed by the EX group (-4.6 ± 3.1 mmHg, p<0.001) and then the MGS group (-2.3 ± 2.7 mmHg, p<0.05). At mid-point (3 week), the EMG group were the only group to have a significant (p<0.05) reduction (-3.57 ± 3.2 mmHg) in SBP. There were reductions in DBP within the EMG group (-4.9 ± 4.4 mmHg, p<0.001) and EX group (-3.4 ± 3.9 mmHg, p<0.05) however none differed significantly between the two groups (p>0.05). They were however higher than the reductions in DBP in the MGS group (-1.0 ± 5.2 mmHg, p>0.05). The reduction in RHR were the highest in the EMG (-10.9 ± 4.0 bpm, p<0.05) followed by the EX (-6.0 ± 4.9 bpm, p<0.001), while the MGS (-2.9 ± 6.1 bpm, p>0.05) group did not have a significant reduction. At the end of the study 19 individuals had achieved pre-hypertension status (SBP 120-139 mmHg and DBP 80-90 mmHg) (EMG; n=7, EX; n=7 and MGS; n=5) from grade 1 hypertension status. Our findings suggest that a combination of exercise and magnesium causes a larger reduction in SBP than exercise or magnesium alone. This combined method also enhances the speed with which this BP reduction occurs. This study suggests that individuals with hypertension can get an enhanced BP lowering effect by combining exercise and magnesium rather than using either one of the methods independently. Secondly, a combination of magnesium and exercise is more effective at reducing RHR than exercise alone, while magnesium supplements do not cause any significant reduction. The study recommends implementation of a combined exercise and magnesium regimen as part of the treatment plan for individuals with Grade 1 hypertension within lower and middle income countries.
CHAPTER ONE: INTRODUCTION

1.1 Background to 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 ≥140/90 mmHg) has severe social, economic and human consequences particularly in poor populations such as Kenya (WHO, 2018). The WHO global status report on non-communicable diseases (2018) states that the age-adjusted prevalence of raised blood pressure (BP) amongst the adult Kenyan population (>18 years) is 20%. 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 8% (WHO, 2018). If a major cardiovascular risk factor such as hypertension is controlled it may reduce the cardiovascular disease burden for the region.

Although hypertension has a high prevalence rate, it has been acknowledged as one of the modifiable risk factors for cardiovascular disease associated with stroke, heart disease and end-stage kidney disease (Hedayati, Elsayed & Reilly, 2011). Since individuals with hypertension have a higher predisposition for cardiovascular disease, premature death may occur in individuals whose BP is poorly controlled (Varughese & Lip, 2005).

The use of non-pharmacological methods has been shown to have the ability to substantially reduce BP in adults with hypertension (Hedayati et al., 2011). The two most recognized non-pharmacological methods used to manage and control BP in adults are:
Increased participation in physical activity and the adoption of a healthy diet (So, Li, Choi, Sung & Nelson, 2012). In addition, an increase in dietary magnesium (Mg) has been shown to lower BP (Kass, Weekes & Carpenter, 2012).

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 and 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 (4 week) exercise (Liu et al., 2012). There are various proposed mechanisms for the reduction of BP through exercise such as:

1. Reduced sympathetic tone (Pagonas et al., 2013) due to decreased nervous system activation (Edwards, Wilson, Sadja, Ziegler & Mills, 2011).
2. Decreased arterial stiffness (Kiviniemi et al., 2015) due to favorable vascular remodeling of elastin and collagen content (Liu et al., 2012).
3. Increased vasodilation through an increase in endothelial nitric oxide synthase (eNOS) activity, thus increasing nitric oxide (NO) (García-Hermoso, Saavedra & Escalante, 2013).
4. Decreased renin activity which leads to vasodilation and decreased blood volume and consequently reduced BP (García-Hermoso et al., 2013).

Studies suggest that dietary Mg supplementation (500-1000mg/day) significantly reduce BP (Bain et al., 2015; Choi & Bae, 2015; Kass et al., 2012; Rosanoff, 2010) with values of up to 12 mmHg (Kass & Poeira, 2015), with higher doses eliciting a higher reduction in BP (Dose dependent relationship) (Jee et al., 2002). Possible mechanisms for reduction in BP by Mg:
1. Acts as a natural calcium channel blocker that induces endothelial-dependent vasodilation.
2. Reduces circulating Na\(^+\) K\(^+\) ATPase inhibitory activity thus decreases vascular tone.
3. Increases vasodilation through an increase in NO.
4. Increases prostaglandin E1 (PGE1) known to cause vasodilation.
5. Induces direct and indirect vasodilation (Houston, 2011).

Previous studies have investigated the BP response to exercise and Mg independently; however there is limited research on the effect of combining a chronic exercise program and Mg supplementation regimen on BP in adults with hypertension. Two studies have investigated the effect of Mg supplementation on resting and recovery BP after exercise (Kass et al., 2013; Kass & Poeria, 2015). These studies did not have any exercise intervention and were investigating acute changes in BP, while the current study had an exercise intervention and focused on chronic BP changes that occurred even after the effects of post exercise hypotension (PEH) have disappeared.

The main aim of this study was to investigate the magnitude of chronic changes in resting BP after a combination of exercise and Mg supplementation in adults with grade I hypertension in Nairobi and Kiambu Counties, Kenya.

There has been a direct correlation between high resting heart rate (RHR) and increased cardiovascular morbidity and mortality in individuals with hypertension (Aune et al., 2017; Böhm, Reil, Deedwania, Kim & Borer, 2015; de Moraes, Cassenote, Moreno & Carvalho, 2014). Increased RHR has also been shown to multiply the effects on all of the stages of the cardiovascular disease continuum from endothelial dysfunction, atherosclerotic lesion formation, plaque rapture to end stage
cardiovascular disease (Custodis, Reil, Laufs & Böhm, 2013). This means, that for BP to be controlled, RHR should also be controlled/reduced.

Thus, the secondary aim of this study was to investigate the magnitude of chronic changes in RHR after a combination of exercise and Mg supplementation in adults with grade I hypertension in Nairobi and Kiambu Counties, Kenya.

The study was undertaken over a 6 week period because studies have shown that the chronic effects of PEH are already present at 5 weeks of exercise (Liu et al., 2012) and the BP lowering effects of Mg are already present 4 weeks (Kass et al., 2012).

In this study exercise and Mg were the independent variables while changes in BP, RHR, weight, waist and hip circumference were the dependent variables.

1.2 Statement of the Problem

The prevalence of hypertension within lower-middle income countries (such as Kenya) has increased due to high cost and poor availability of anti-hypertensive medications, consequently increasing the cardiovascular disease burden (Twagirumukiza & Van Bortel, 2010). Individuals with hypertension do not get appropriate care because they cannot afford the medication and treatment which leads to secondary cardiovascular diseases associated with raised BP.

The age-adjusted prevalence of raised BP (>18 years) is 20% amongst the Kenyan adult population (WHO, 2018) 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. Secondly, for every 10 bmp increase in RHR, there is an 8% increase in cardiovascular mortality (Zhang et al., 2015), which
means RHR must also be reduced to ensure that the cardiovascular disease burden is controlled.

Since exercise can be conducted in any open space at no cost and Mg supplements cost a fraction of anti-hypertensive medications, combining these two economical methods, as done in the study, may be the solution. That will allow increased access to hypertensive care by lowering treatment cost.

1.3 Purpose of the Study

The purpose of this study was to investigate the effect of a 6 week combined exercise and Mg supplementation regimen on resting BP and RHR in adults with Grade I hypertension in Nairobi and Kiambu Counties, Kenya.

1.4 Objectives of the Study

The general objective of this study was to determine the combined chronic effect on resting BP and RHR after a 6 week exercise and Mg supplementation regimen in adults (30-60 years) with grade I hypertension within Nairobi and Kiambu Counties, Kenya.

The study was guided by the following primary objectives:

1. To report on the change in anthropometrics after 6 weeks of exercise, Mg or combination of exercise and Mg in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

2. To assess the change in resting BP following a 6 week exercise regimen in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.
3. To assess the change in resting BP following a 6 week Mg supplementation regimen in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

4. To assess the change in resting BP after a 6 week combined exercise and Mg supplementation regimen in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

5. To compare the effects on resting BP between the 3 groups after 6 weeks of exercise, Mg supplementation or a combination of both exercise and Mg in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

The study was guided by the following secondary objectives:

1. To compare the relationship between RHR and BP in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

2. To assess the change in RHR after a 6 week exercise regimen in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

3. To assess the change in RHR after a 6 week Mg supplementation regimen in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

4. To assess the change in RHR after a 6 week combined exercise and Mg supplementation regimen in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.

5. To compare the effects on RHR between the 3 groups after 6 weeks of exercise, Mg supplementation or combination of both exercise and Mg in grade 1 hypertensive adults (30-60 years) within Nairobi and Kiambu Counties, Kenya.
1.5 Hypothesis

The study was guided by the following hypothesis:

1. \( H_{01} \) - There is no significant difference in the changes observed in resting BP in adults with grade I hypertension following a 6 week exercise regimen.

2. \( H_{02} \) - There is no significant difference in the changes observed in resting BP in adults with grade I hypertension following a 6 week Mg supplementation regimen.

3. \( H_{03} \) - There is no significant difference in the changes observed in resting BP in adults with grade I hypertension following a 6 week combined exercise and Mg supplementation regimen.

4. \( H_{04} \) - There is no significant difference in the changes observed in resting BP between the 3 groups following a 6 week exercise, Mg or combined exercise and Mg supplementation regimen.

5. \( H_{05} \) - There is no significant difference in the changes observed in RHR in adults with grade I hypertension following a 6 week exercise regimen.

6. \( H_{06} \) - There is no significant difference in the changes observed in RHR in adults with grade I hypertension following a 6 week Mg supplementation regimen.

7. \( H_{07} \) - There is no significant difference in the changes observed in RHR in adults with grade I hypertension following a 6 week combined exercise and Mg supplementation regimen.

8. \( H_{08} \) - There is no significant difference in the changes observed in RHR between the 3 groups following a 6 week exercise, Mg or combined exercise and Mg supplementation regimen.
1.6 Significance of the Study

The results from this study could offer hypertensive adults a more affordable long term BP and RHR management plan. This in turn could lead to the lowering of the hypertension prevalence and cardiovascular disease burden in Kenya and sub-Saharan Africa.

Health care professionals and institutions may have a safer alternative method of long term management of BP and RHR that does not include pharmacological methods that have numerous side effects to patients.

This study offers a basis for the government to introduce health policies and initiatives that involve physical activity and Mg supplementation as a method of controlling BP and RHR in the country.

At the community level exercise will now be more affordable due to the fact that the circuit training made of everyday items can be easily acquired by individuals.

1.7 Delimitations of the Study

This study was delimited to adults with grade I hypertension from Kenyatta University and Thika Level 5 hospital who satisfied the inclusion criteria. The study focused on individuals with grade 1 hypertension because, the Joint National Committee 8 (JNC 8) guidelines for management of high BP (2014) and the American college of sports medicine (ASCM) position stand for exercise and hypertension (2004) suggest lifestyle modification as a first line treatment for individuals with grade 1 hypertension (SPB ≥140-159 & DBP ≥90-99) without any other risk factor.
The exercise training was undertaken at Kenyatta University and Thika Level 5 hospital 5 times a week. Mg supplements were dispensed at both Kenyatta University and Thika Level 5 Hospital at the beginning of every week. The study focused on chronic BP and RHR changes. Acute BP and RHR changes were not recorded.

1.8 Limitations of the Study

One limitation in this study was that intracellular Mg levels were not measured before and after the study to determine whether there was an increased Mg uptake within the cells. The test was not performed due to the fact that it was not available within the country. The reason serum magnesium levels were not measure was due to the fact that extracellular magnesium blood tests (i.e. serum) do not accurately show the magnesium stored in the body, since less than 2% in present in the extracellular space (Wang, Van Den Eeden, Ackerson, Salk & Reniece, 2009). So findings from this test would not accurately give information on changes in magnesium within the cell.

The second limitation of the study was that fitness tests were not performed to determine whether the BP lowering effects of the combined exercise and Mg group was due to direct mechanisms or were due to increased exercise tolerance. These tests were not performed because appropriate equipment to safely perform the tests was not available in the country. Over all therefore, conclusions were drawn based on the BP reductions alone.

1.9 Assumptions of the Study

This study was based on the assumption that BP and RHR changes were due to exercise, Mg, or a combination of both and no other external factors such as psychological factors (e.g. stress). Subjects were restricted from engaging in any
activities or taking any form of medication and supplement that would aid in reduction of BP. At the point of recruitment the subjects were not engaging in external activities or taking any supplement or medication that would assist in lowering BP.

The second assumption was that oral Mg led to a good bioavailability across all the subjects thus leading to equal absorption and increase in intracellular Mg levels.

1.10 Conceptual Framework

The conceptual framework was based on the PRECEDE model which examines the cause of health problems (Figure 1.1).

![Conceptual Framework Diagram]

**Figure 1.1 Conceptual framework on the combined effect of exercise and magnesium on blood pressure**

The framework was based on the modified PRECEDE model on the approach taken towards individuals with hypertension (Gallani, Cornélio, Agondi & Rodrigues,
The section of the model that was used to develop this conceptual framework reinforced that hypertensive behavior (exercise and nutrition) has a causal relationship with the development and progression of cardiovascular risk factors. If the behaviors are reversed the risk factors are controlled (Gallani et al., 2013).

This model proposes that behaviors (nutrition and physical activity) are linked to hypertensive outcome. The lack of adherence to proper nutrition or physical activity causes risk factors while adherence to proper physical activity and nutrition allows disease to be controlled. This means that adherence to exercise and magnesium intake leads to better control of the disease while lack of adherence to exercise and magnesium intake leads to poor control of the disease. Secondly, the combination of both nutrition and physical activity may lead to an enhanced hypertensive control method. In this concept, Mg supplements falls under nutrition and exercise falls under physical activity.

Since exercise has been shown to reduce BP by decreasing sympathetic tone (Pagonas et al., 2013), increasing NO (Garcia-Hermoso et al., 2013), decreasing renin activity (Garcia-Hermoso et al., 2013) and decreasing arterial stiffness (Kivinemi et al., 2015); While Mg has been shown to reduce BP by improving endothelial function, suppressing Na⁺ K⁺ ATPase, increasing NO, increasing PGE1 and blocking of calcium channels (Houston 2011); it could be stipulated that the combination of the two will provide an enhanced BP lowering effect.
CHAPTER TWO: LITERATURE REVIEW

2.1 High Blood Pressure

Hypertension is raised BP level of ≥140 mmHg for systolic ≥90 mmHg for diastolic BP (WHO, 2018).

There are different BP grading systems and the current study used the WHO (2018) hypertension classification system as shown in Table 2.1.

Table 2.1 Hypertension Classification (WHO 2018)

<table>
<thead>
<tr>
<th>Category</th>
<th>Systolic Blood Pressure</th>
<th>Diastolic Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1 Hypertension</td>
<td>140-159</td>
<td>90-99</td>
</tr>
<tr>
<td>Grade 2 Hypertension</td>
<td>160-179</td>
<td>100-109</td>
</tr>
<tr>
<td>Grade 3 Hypertension</td>
<td>≥180</td>
<td>≥110</td>
</tr>
</tbody>
</table>

There are two non-invasive methods of measuring BP: Automatic oscillometric technique and manual auscultatory technique. Oscillometric devices (automated) have been shown to be less accurate than auscultatory devices (non-automated devices) (Skirton, Chamberlain, Lawson, Ryan, & Young, 2011). Though oscillometric devices appear sufficiently accurate for clinical use, in special circumstances such as in individuals with hypertension, this method could be highly inaccurate (>15 mmHg, 5% of the time). Since small BP changes in individuals with hypertension were being recorded the current study used the Mercury Sphygmomanometer, which is a manual device.

Manual BP readings are usually taken at the upper arm (Kurtz, 2005). The stethoscope is placed at the elbow crease over the brachial artery.
Other sites that BP measurements can be taken are the wrist and the fingers. However, in these sites systolic blood pressure (SBP) increases with distal arteries while diastolic blood pressure (DBP) decreases with distal arteries (Kurtz, 2005). Wrist monitors sometimes have systematic errors induced by the hydrostatic effect relative to the heart, while finger monitors are inaccurate (Kurtz, 2005). Thus this study measured BP at the Brachial Artery.

2.2 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 individuals with hypertension. Although this mechanism is not yet fully understood, the roles of oxidative stress, the renin-angiotensin-aldosterone system and inflammation have been suggested (Edwards et al., 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 (Al) and BP following chronic exercise. The Al 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 et al., 2012).

Exercise has also been shown to reduce BP by increasing eNOS activity and expression (García-Hermoso et al., 2013). An increase in eNOS will increase 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 et al., 2011; Liu et al., 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).

BP can be lowered transiently after acute exercise (one exercise session), and this effect is often termed PEH, and the degree of this change has been related to the magnitude of change in BP observed after chronic exercise (Liu et al., 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 et al. (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. Results showed that BP was significantly reduced by 7.2/4.2 mmHg following acute exercise and by 7.0/5.2 mmHg 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 BP following exercise, in the maintenance of long term (chronic) BP 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 et al., 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.

2.3 Magnesium and Blood Pressure

One of the mechanisms by which Mg lowers BP is by functioning as a calcium channel blocker by extracellularly inhibiting transmembrane calcium transport and calcium entry, or acting intracellularly as a calcium antagonist (Hatzistavri et al., 2009). This controls the vasoconstriction actions caused by increased intracellular calcium. Mg competes with the sodium binding sites of smooth muscles thus increasing circulating levels of PGE-1. This causes co-operative binding to potassium, which prompts vasodilation via decreased intracellular calcium and sodium levels thereby reducing BP (Choi and Bae, 2015; Houston, 2011; Kass et al., 2012)

Mg also regulates BP by mediating the action of Na\(^{+}\) K\(^{+}\) ATPase which regulates transmembrane sodium and potassium transport. An increase in Mg levels causes suppression of Na\(^{+}\) K\(^{+}\) ATPase inhibitory activity which in turn reduces vascular tone (Mubagwa, Gwanyanya, Zakharov & Macianskiene, 2007; Touyz, 2004).

Studies have shown that there is an inverse relationship between serum Mg levels and BP (Rosanoff, Weaver & Rude, 2012). Oral Mg supplementation increases intracellular Mg levels and causes a significant reduction in intracellular calcium and sodium concentrations.
A study by Hatzistacri et al. (2009) showed that this subsequent increase in Mg levels and decrease in sodium and potassium levels following oral Mg supplementation reversed the impaired ionic balance present in individuals with hypertension, thus proposing it as one of the basic mechanisms through which Mg exerts its BP lowering effect.

Mg has also been shown to influence BP through the mediation of NO (Barbagallo, Dominguez, Galioto, Pino & Belvedere, 2016; Lui, 2003) and PGE1 (Das, 2006: 2010). NO is a powerful vasodilator and an increase in Mg levels has been shown to increase NO levels in the body (Barbagallo at al., 2016; Lui, 2003). Increase in Mg has also been shown to stimulate the release of PGE1 which causes an increase in vasodilation in the blood vessels thus reducing BP (Das, 2006, 2010).

Studies have shown that high Mg intake (500 – 1000 mg/day) may reduce BP but these results are inconsistent (Houston, 2011; Choi & Bae, 2015). However, these inconsistencies may have been brought about by variation in: the population studies, type and dosage of Mg, pre-treatment BP levels, duration of the trial, dietary nutrients and minerals (Jee et al., 2002; Touyz, 2004).

In a uniform sub set meta-analysis of seven studies that involved 135 individuals with hypertension on anti-hypertensive medication for at least 6 months and no more than 2 weeks wash out period demonstrated a mean change of -18.7 mmHg after Mg supplementation (Rosanoff, 2013). However, two other meta-analysis; one conducted by Jee et al. (2002) which involved 20 studies (n=1220) and another conducted by Kass et al. (2012) which involved 22 studies (n=1173) showed very minimal but statistically significant changes in BP.
Jee et al. (2002) study showed an estimated change of 0.6 (-2.2 to 1.0) mmHg for SBP and -0.8 (1.9 to 0.4) mmHg for DPB while Kass et al. (2012) showed an overall change of 3-4 mmHg for DPB and 2-3 mmHg for SBP. Another review done by Dickinson et al. (2006) which involved 12 RCTs (n=544) showed a small average reduction of 2.2 mmHg. The uniform sub set of 7 studies (Rosanoff, 2013) showed a strong effect of Mg treatment in hypertension (-18.7 mmHg) which was in contrast with the other 3 studies. This suggests that the small effect reported by the other 3 studies may have been due to the fact that the non-uniform sets of studies used acted to seriously underestimate the potential of Mg in some (but not all) subjects.

Mg deficiency may play a pathogenic role in the development of hypertension (Kisters & Grober, 2013). A study by Kisters et al. (2011) showed a reduction of -10.4 mmHg in Borderline Mg deficient individuals with hypertension following Mg supplementation (240-480mg/day) over 12-15 weeks. This suggests that individuals, whose hypertension developed due to Mg deficiency, can control their BP using Mg supplements and have an improved quality of life. Mg has however also been shown to reduce BP in individuals without any disturbances in Mg metabolism (Solati et al., 2014). In a study by Solati et al. (2014) on people with type II diabetes who did not have obvious disturbances in Mg metabolism, subjects showed average reductions of 15.1 mmHg and 10.6 mmHg in DPB and SBP respectively following Mg (MgSo4-) supplementation (300 mg/day) over a 3 month period.

Other studies have shown that there is a dose dependent relationship between Mg intake and BP (Choi & Bae, 2015; Jee et al., 2002; Kass et al., 2012; Rosanoff, 2010). A meta-analysis by Jee et al. (2002) showed reductions of -4.3 mmHg SBP and -2.3 mmHg DPB for each 10 mmol/day increase in Mg dosage.
Another study by Kass et al. (2012) showed that after sub analysis for dosage was conducted (<370mg mg and >370mg mg/day), both DPB and DPB showed higher efficacy of Mg supplementation at higher doses.

Since the current literature suggests that results from previous studies may have been affected by non-homogeneous population, type of Mg supplement and dosage; this study strived to ensure that the population was as homogenous as possible by restricting the pretreatment BP levels to grade I hypertension, the age group to 30-60 years, sedentary, drug & supplement naive without any secondary diseases.

2.4 Combination of Magnesium and Exercise on Blood Pressure.

Although there has been comprehensive research on the independent effects of exercise and magnesium’s respectively on BP, there is limited research done on the effect of combining an exercise program and Mg supplements on BP in individuals with hypertension. Nonetheless, there have been two studies conducted to investigate the effects of Mg supplementation on resting and recovery BP after exercise (Kass et al., 2013; Kass & Poeira, 2015).

The study by Kass et al. (2013) was a pilot study investigating the effect of Mg supplementation on resting and recovery SBP after aerobic or resistance exercise on normotensive individuals. The study was conducted on 16 male (19-24 years) individuals who were randomly assigned to either a 300 mg/day Mg oxide supplementation group or a control group over a duration of 14 days. The subjects performed a maximal 30 min cycle, followed three x 5 second isometric bench press, at baseline and post-test. BP was measured before the exercise, immediately after and 5 minutes after recovery. This study demonstrated that Mg caused a reduction in
SBP (-8.9 mmHg) which was higher than the reduction in the control group (-0.8 mmHg).

The second study was by Kass and Poiera (2015) on 13 recreational runners; cyclists or triathletes (7 males and 6 females) over a 4-week duration and investigated the effects of acute (1 week) vs chronic (4 week) supplementation on recovery BP following exercise. The mean age of the subjects in the chronic group was 40.8 and the acute group was 35.8. Subjects were placed in either a 300mg/day Mg supplement for 1 week or 4 weeks. A 40km time trial followed by an 80 % 1RM bench press was performed to exhaustion at baseline and posttest (1 week and 4 weeks for both groups) where BP measurements were taken before and after the test. The reduction in SBP (-2 mmHg and -0.7 mmHg) within acute and chronic Mg loading groups were higher than in the control group. The conclusion from these two studies was that oral Mg supplementation significantly reduces post exercise and resting BP.

The major difference between the two studies above (Kass et al., 2013; Kass & Poiera, 2015) and the current study is that the two studies above were looking at the effect of Mg supplementation on recovery exercise without providing an exercise intervention. This means that the results gathered from the two studies above (Kass et al., 2013; Kass & Poiera, 2015) were as a result of the BP lowering mechanisms of Mg only and not exercise. The current study, on its part, investigated whether combining an exercise program and Mg supplementation will cause larger reduction in BP than using exercise or Mg alone.

The two studies above measured acute changes in BP with measurements being taken immediately and 5 minutes after exercise, which meant they were looking at
the effects of PEH. The current study focused on chronic changes in BP so as to determine whether the changes in BP were long term after the effects of PEH have worn off, hence determining whether the protocol would assist with long term BP management.

The above studies only focused on normotensive individuals. The current study looked at this same combined effect but on individuals with grade I hypertension.

The two studies above did not determine the direct influence their Mg supplement protocol had on BP. This means that they did not determine the extent to which BP was lowered by their Mg supplementation protocol. Since Mg supplementation protocols affect the level of BP reduction (Banjanin & Belojevic, 2018; Rosanoff, 2013), the current study included a Mg only group to determine the independent effects of the specific Mg supplementation protocol on BP which the above studies did not account for.

So the results from this study may be a first of its kind when looking at combining a Mg supplementation protocol and an exercise regimen to enhance the chronic BP lowering effect than using one method independently.

2.5 Relationship between Resting Heart Rate and High Blood Pressure

Heart rate is the number of ventricular contraction per minute, with these contractions fluctuating substantially with changes in systemic oxygen demand (Silva, Lima & Tremblay, 2018). Heart rate is a none-invasive and simple method of measuring health related prognoses (Christofaro, Casonatto, Vanderlei, Cucato & Dias, 2017).
Epidemiological evidence has shown a direct correlation between high cardiovascular morbidity and mortality and increased RHR within the patients with cardiovascular disease such as individuals with hypertension because RHR is known to be a sensitive indicator of the autonomic nervous system (Aune et al., 2017; Böhm, Reil, Deedwania, Kim & Borer, 2015; de Moraes, Cassenote, Moreno & Carvalho, 2014). This is due to the fact that the rate of depolarization of the sino-atrial node is determined by the activity of the autonomic nervous system.

Therefore, RHR is controlled by sympathetic activity and elevated RHR is characterized by sympathetic over reaction (Inoue & Ohya, 2011). This imbalance stimulates the renin-angiotensin-aldosterone system, which leads to increased release of angiotensin II, which in turn has a negative effect on the development and progression of atherosclerosis (Inoue & Ohya, 2011). It is possible that the imbalance between sympathetic and parasympathetic activity may contribute to the relationship observed between increased RHR and hypertension and/or cardiovascular disease risk (Perret-Guillaume, Joly & Benetos, 2009).

Thus increased RHR has emerged as a risk factor in individuals with hypertension and other cardiovascular diseases with a suggested pathogenic role. Increased RHR has multiplying effects on all of the stages of the cardiovascular disease continuum from endothelial dysfunction, atherosclerotic lesion formation, plaque rapture to end stage cardiovascular disease (Custodis, Reil, Laufs & Böhm, 2013). This suggests that an elevated RHR can increase the deteriorative effects of high BP on the cardiovascular system by increasing myocardial fatigue, oxygen consumption and damage elastic fibres within the walls of the arteries, further advancing atherosclerotic lesion formation and consequence (Perret-Guillaume et al., 2009).
If not controlled it increases the progression of coronary atherosclerosis, on occurrence of ventricular arrhythmia, myocardial ischemia, left ventricular function and inflammatory marker levels (Zhang, Shen & Qi, 2015). So RHR reduction may inhibit inflammation and plaque formation because it is suggested that HR is directly involved in atherosclerosis formation process independent of sympathetic activity with the HR having atherogenic effects (Inoue & Ohya, 2011). So reversing the harmful effects of high RHR may be beneficial to individuals with hypertension to ensure that the deteriorative effects brought about by raised BP do not occur or advance.

A systematic review and dose dependant meta-analysis carried out by Aune et al. (2017) investigated the strength, direction and shape of the dose-dependent relationship between RHR and cardiovascular outcomes. They found a linear dose depend relationship of increase risk of 15% for cardiovascular disease, 7% for coronary heart diseases, 9% for sudden cardiac death, 18% for heart failure and 6% for stroke for each 10 bpm increase in RHR. A second meta-analysis was by Zhang et al. (2015) which aimed to look at the cardiovascular mortality and not cardiovascular risk. The results suggested an 8% increase in cardiovascular mortality for every 10 bpm increase in RHR. They also observed a significant increased risk of cardiovascular mortality at 90 bpm. However the main concern is whether high RHR is an independent predictor because high RHR co-exist with traditional risk factors of poor health and cardiovascular disease. The meta-analysis suggested that the relationship between the RHR and cardiovascular mortality is independent of traditional risk factors of cardiovascular disease, which suggest that RHR is a good predictor of mortality in the general population. The study by Aune et al. (2017) found a stronger association with a 16% increase in the relative risk for every 10 bpm
increase in RHR compared to a 9% increase in the study by Zhang et al. (2015). The study by Aune et al. (2017) included 20 more additional studies than the study by Zhang et al. (2015) in the analysis that may have contributed to a stronger association however increased the heterogeneity of the study.

Since the literature above shows a very strong relationship between RHR and BP and/or cardiovascular disease, RHR was included in the current study as secondary outcome measure.

2.6 Exercise and Resting 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 et al., 2018).

The two proposed mechanisms for this reduction in RHR are:

1. 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 to 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 RHR (Bellenger et al., 2016; da Silva et al., 2013; Snoek, van Berkel, van Meeteren, Backx & Daanen, 2013)
2. High levels of aerobic fitness cause an increase in parasympathetic nervous activity while reducing sympathetic nervous system activity thus increasing vagal tone and reducing RHR (da Silva et al., 2013).

3. 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 et al., 2018).

A study by Schroeder et al., (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 was lower for elevated RHR after adjusting for confounding factors. This study showed the relationship between higher cardiorespiratory fitness or exercise participation and lower RHR.

A study by Silva et al. (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. The study, 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 current study. The results were similar to the study by Schroeder et al. (2017) where the study population was 30-64 years which is a similar age group to the current study. In the study by Silva et al. (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 had 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 current study included in the exercises program. Notably, the studies above only looked at the relationships and no interventions were provided.

An exercise intervention study was by Fløtum et al. (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 mean arterial pressure (MAP) and the recovery HR at 1, 2, and 3 minutes of Yo-Yo running test was reduced, which suggests lowered sympathetic activity at rest and at elevated stroke volume during exercise. The results were similar to a study by Mathunjwa, Semple and Du Preez (2016) on 67 obese but
healthy women (mean age of 25) African female students where the reduction in RHR was -7.5 bpm after a 10 week aerobic exercise program.

2.7 Magnesium and Resting Heart Rate

The studies directly investigating the relationship between Mg and RHR are very limited. However Mg is involved in many physiological, biochemical and cellular processes that regulate cardiovascular function (Kolte, Vijayaraghavan, Khera, Sica & Frishman, 2014). Mg has been shown to improve endothelial function, vascular smooth muscle tone, myocardial excitability and blood flow in systemic and coronary circulation (Houston, 2011) thus mediating heart rate indirectly by improving cardiovascular function.

Mg improves cardiovascular function by:

1. Reducing vascular tone: Mg is a natural calcium blocker, thus inducing endothelial dependent vasodilation. Endothelium plays a crucial role in vascular homeostasis by regulating vascular diameter and tone, coagulation factors, vascular inflammation and cell migration and proliferation. There is also a reduction in arteriolar tension and tone in various arteries and an increase in the dilatory action of endogenous and exogenous vasodilators. Mg has also been shown to reduce circulating Na⁺ K⁺ ATPase inhibitory activity thus decreasing vascular tone and increasing vasodilation through an increase in NO. These factors reduce systemic and pulmonary vascular resistance with an accompanying reduction in BP and slight increase in cardiac output and function. (Houston 2011; Shechter, 2010) This increase in cardiac output may lead to a decrease in the number of beats required to maintain resting cardiac output.
2. Improving left ventricular ejection fraction (LVEF) and resting myocardial function. A study by Pokan (2006) on 53 male patients with stable coronary artery disease were either given oral Mg 15 mmol twice daily or placebo for 6 months. After the 6 months investigation there were marked improvements in LVEF. A larger ejection fraction is suggestive of an increased cardiac output and function. This increase in cardiac output may lead to a decrease in the number of beats required per minute. Mg also resulted in significant decrease in left ventricular diastolic dysfunction (LVDD) and left ventricular systolic dysfunction (LVSD) suggestive of a cardio protective trait of Mg.

Since a lower RHR is a good indicator of cardiovascular health (da Silva et al., 2013), improving cardiovascular function through Mg supplementation may reduce RHR.

2.8 Combination of Exercise and Magnesium on Resting Heart Rate

Since exercise has been shown to reduce RHR (Fløtum at al., 2016; Park et al., 2018; Schroeder et al., 2017; Silva et al., 2018) and Mg has been shown to regulate/improve cardiovascular function (Kolte et al., 2014), it is suggested that the combination of the two will lead to a higher reduction in RHR.

A pilot study by Kass et al. (2013) on 16 normotensive individuals investigated the effects of Mg supplements (300 mg/day Mg oxide) on RHR (secondary outcome measure) after aerobic and resistance exercise after 14 weeks. After the 14 week intervention there was a reduction in RHR of 6 bpm in the control group and 7 bpm in the supplemented group. In the study, however, there was no exercise protocol prescribed rather the exercise was used at baseline and posttest suggesting that the enhanced RHR lowering effects was due to Mg.
2.9 Summary of Literature Review and Research Gap

The literature review exhaustively elaborates the physiological mechanisms employed and effects elicited by Mg and exercise on BP. This information was used to:

1. Determine the appropriate Mg dosage to be used to elicit the highest BP lowering effect.
2. Determine the appropriate Mg subtype to be used.
3. Determine exercise parameters (frequency, intensity, time and type) that would provide the highest BP reduction while still maintaining the safety of the subjects.

Since increased RHR has been shown to have a multiplying effect on all stages on the cardiovascular disease continuum, controlling it is important, especially for individuals with hypertension, thus it has been included as a secondary outcome measure in the current study.
CHAPTER THREE: METHODOLOGY

3.1 Research Design

This study employed a pretest-posttest experimental research design because specific conditions were controlled and effects observed at baseline and after the study was completed. In this case, exercise and administration of Mg was controlled by the researcher and the influences on resting BP, RHR and anthropometric data (weight, waist and hip circumference) were observed. Groups were also divided into experimental and control groups.

3.2 Measurements of Variables

3.2.1 Independent Variables

i) Exercise was performed 5 times a week, for 45 minutes and intensities were maintained at 40≤60% of VO₂max. ii) 500mg of Mg Citrate supplement was given twice a day.

3.2.2 Dependent Variables

i) SBP and DBP were measured using a mercury Sphygmomanometer (Rudolf Reister GmbH, Bruckstr, Jungingen, Germany). ii) RHR was measured using a heart rate monitor (Garmin, Olathe, Kansas, US). iii) Height and weight were measured using a Stadiometer (Jiangsu Suhong Medical Instruments Co., China). iv) Hip and waist circumferences were measured using a tape measure.
3.3 Study Location

The study was conducted at Kenyatta University in Nairobi County and Thika Level 5 Hospital in Kiambu County. The two locations were selected as a result of urbanization that has been described as a key driver of the evolving non-communicable disease (NCD) epidemic such as hypertension (Joshi et al., 2014). Kiambu is experiencing a rise in the urban population because it borders Nairobi with the Hospitals having a catchment population of almost 101,596 (Meme, Amwayi, Nganga & Buregyeya, 2015). This made Kiambu an ideal area to carry out the study so as to recruit individuals with the earlier stages (grade I) of hypertension with Kenyatta University being right at the border of Nairobi and Kiambu Counties and Thika Level 5 Hospital being within Kiambu County. Both Locations have high levels of foot traffic thus ensured maximum participation during the free BP drive.

3.4 Target Population

The target population was adults aged between 30-60 years who presented themselves during the BP screening day held at Kenyatta University and Thika Level 5 Hospital that was scheduled by the researcher. The age group 30-60 years was selected due to the fact that in lower and middle income countries individuals within the middle aged group have the highest hypertensive burden (Mills et al., 2016), with this age bracket having 15-19 % chance of dying from the disease (WHO, 2018).
3.5 Inclusion Criteria

The inclusion criteria used in recruiting the subjects were:

i) Both men and women were included in the study because guidelines recommend a similar approach to hypertension management for both genders (Daugherty et al., 2011). ii) Adults aged between 30-60 years because this was the age group with the largest hypertensive burden (Mills et al., 2016). iii) Individuals with Grade I hypertension (SBP $\geq$140-159 mmHg and DPB $\geq$90-99 mmHg) because lifestyle modification is the first line of treatment of individuals within this group (ACSM, 2004; JNC, 2014). iv) Individuals who had a sedentary lifestyle who did not engage in any organized physical activity or perform moderate intensity walking > 30 minutes a day. This was determined during recruitment phase at the blood pressure drive.

3.6 Exclusion Criteria

The exclusion criteria used in recruiting the subjects were:

i) Any individual on antihypertensive medication. This ensured that the BP lowering effects of the research participants were due to exercise or magnesium alone. ii) Non-Smoker (within the past one year) were not included because smoking has been shown to increase BP (Gumus, 2013). iv) Individuals with secondary hypertension, stroke, coronary artery disease, severe congestive heart failure, active liver disease chronic, kidney disease, diabetes mellitus and history of malignancy were not included in the study because they would not be able to participate safely in the current exercise protocol for individuals with grade I hypertension. v) History of alcohol and recreation drug abuse (e.g. Amphetamines, Cocaine, Ecstasy/MDMA which have been shown to increase BP) (Briasoulis, Agarwal & Messerli, 2012).
vi) Any individual on an dietary supplements were excluded from the study because some dietary supplements have been shown to increase or lower BP, while some of the effects on BP are unknown (Rasmussen, Glisson & Minor, 2012). vii) Any individual who failed the health screening (APPENDIX B), which excluded individuals who were not be able to participate in the exercise program due to specific medical conditions. viii) Any individual who was pregnant or physically disabled because they would not be able to safely participate in the current exercise program due to the frequency, intensity, time and type of exercises which are specific to individuals with grade I hypertension.

3.7 Sample Size and Sampling Technique

The sample size was calculated using G*Power 3.1.9.2 (P a=0.05, Power=0.95, Effect size (F2) =0.25, number of groups=3, number of predictors=2 and response variables=5). A factorial MANCOVA test was selected as the test family because the study sought to determine whether or not exercise and Mg supplements (and their interactions) significantly affected BP. The specific statistical test selected was a MANOVA special effects and interactions and the type of power analysis used was A Priori. The suggested sample size that would give the desired effect was calculated as 50 subjects. So as to account for dropout, an extra 20 subjects were recruited and divided equally amongst each group. This study used systematic sampling and subjects were then divided into the following groups: EX=23, MGS=23 and EMG=24 (n=70). However at the end of the study the groups were as follows: EX=15, MGS=18 and EMG=14 (n=47). This was due to the fact that individuals were excluded if they did not achieve a minimum of 80% adherence with exercise or did not collect their Mg supplements at the beginning of the week.
3.8 Research Instruments

3.8.1 Mercury Sphygmomanometer (Rudolf Reister GmbH, Bruckstr, Jungingen, Germany)

Since auscultatory devices (non-automated devices) are more accurate than oscillometric devices (Skirton et al., 2011), the mercury sphygmomanometer was used to detect the pre and post-test changes in BP.

3.8.2 Heart Rate Monitor (Garmin, Olathe, Kansas, US)

This device was used to provide real time feedback about RHR and exercise intensities using telemetry (VO₂max% and HR) for each individual. VO₂max calculations are based on the first-beat method which calculates height, weight, age, gender, internal workload (HR) and external workload. The entire package consisted of a heart rate monitor, a receiver and software (Self loops heartbeat analysis software) that visualized the data. This device provided real-time information on VO₂max. A study by Montgomery et al (2009) established that this method of estimating VO₂ max typically varied by -6% in comparison with criterion measures of calibrated expired gas analysis system. Therefore, when calculating %VO₂ intensities for individuals this variation of -6% was accounted for. The strap was tied around the chest, just below the chest muscles and was worn over the entire duration of the 45 minutes exercise program.

3.8.3 Suhong RGZ-120 Stadiometer (Jiangsu Suhong Medical Instruments Co., China)

This device was used to measure height and weight of the participants. Weight was measured to the nearest 0.1 kg while height was measured to the nearest 0.1 cm.
3.8.4 Magnesium Citrate Supplement (Now, Bloomingdale, IL, US)

The Mg Citrate (Now, Bloomingdale, IL, US) was in powdered form, capsulated into hard gelatin capsules (size 0) (Sunil healthcare, Nairobi Kenya). The dosage used in this study was a total of 500 mg/day because studies have shown that an intake of 500 mg/day to 1000 mg/day may reduce BP (Houston, 2011). This study used Mg citrate (Now, Bloomingdale, IL, US) because research has shown that organic forms of Mg supplementation such as Citrate tend to exemplify a greater solubility and bioavailability in comparison to inorganic forms such as carbonate and oxide (Kass & Poeira, 2015). Mg Citrate is a preparation that has been approved for sale and distribution in Kenya by the Pharmacy and Poisons Board for supplementation use.

3.8.5 Exercise Program

Exercise protocols used were according the ACSM (Pescatello et al., 2004; Pescatello at al., 2015) guidelines for BP reduction in people with hypertension based on the FIIT principle (Frequency, intensity, time and type):

1. Frequency: exercise was performed 5 times a week so as to ensure that the effects of PEH were maintained throughout the duration of the study.

2. Intensity: exercise intensities were maintained at 40≤60 VO2max because these are the intensities that individuals with grade 1 hypertension can safely exercise while reaping the BP lowering effects of exercise.

3. Time: the exercise was performed for 45 minutes because the effects of PEH are present >30 min of exercise.

4. Type: the protocol included both aerobic and resistance exercise because both have shown merit in reducing BP.
5. Duration: The exercise program was undertaken over a duration of 6 weeks because studies have shown that the chronic effects of PEH are present after 4 weeks of exercise (Liu et al., 2012).

The exercise protocol (APPENDIX D) was a circuit that comprised of 6 zones/stations (3 aerobic training zones and 3 resistance training zones). Zone 1, 3 and 5 were the resistance training zones and zone 2, 4 and 6 were the aerobic training zones. All the exercise selected were simple exercises because majority of the subjects had never exercised before. The primary researcher and research assistants monitored each training session to ensure that proper form and intensity were being maintained. The subjects performed a 5 minute warm up, followed by a 30 minute main set (5 minutes within each zone) and finally completed a 10 minute cool down. The subjects performed 3 sets of each exercise for 15 repetitions with 1 minute break in between each set, which allowed the subjects to maintain the prescribed exercise intensity.

The 6 week exercise protocol was as follows in each of the zones:

1. Zone 1: This was a lower body resistance exercise zone that was comprised of kettle bell squats.

2. Zone 2: This was an aerobic training zone that was comprised of interval cycling.

3. Zone 3: This was an upper body resistance training zone that was comprised of weighted push-ups (5kgs).

4. Zone 4: This was an aerobic training zone that was comprised of skipping.

5. Zone 5: This was a full body resistance training zone that was comprised of tire pushes.
6. Zone 6: This was an aerobic training zone that was comprised of interval running.

3.9 Pilot Study & Pre-Testing of Equipment

Ten (10) hypertensive subjects were recruited from a preliminary BP screening day at Kenyatta University and invited to participate in the pilot study. Two (2) research assistants were recruited from Kenyatta University’s Exercise and Sport Science department and trained by the primary researcher on how to safely conduct an exercise training session with HR monitoring and how to accurately measure anthropometric data of individuals. They were also given a tutorial on the basic physiology of BP and the different BP management methods.

Two (2) nurses were recruited to measure BP using the Mercury Sphygmomanometer (Rudolf Reister GmbH, Bruckstr, Jungingen Germany).

The heart rate monitoring system (Garmin, Olathe, Kansas, US) was tested on subjects by the research assistants during a simulated exercise program similar to the one in APPENDIX D so as to ensure training intensities of 40≤60% of VO₂ max could be maintained and correctly monitored effectively for the entire group during the actual training sessions.

Height, weight, hip and waist circumferences were taken and tested for repeat measurement accuracy.

3.8.6 Validity and Reliability

The mercury sphygmomanometer has been shown to be the most accurate method of measuring BP of individuals with hypertension (Skirton et al., 2011) with an error rate of ≤1 mmHg making it very reliable (Hogue, 2008).
Heart rate telemetry (remote signaling and visualization of real time HR data) has been shown to be a useful method of estimating VO$_2$ max in the field without laboratory calibration (Smolander et al., 2008). Since this technology has been shown to typically vary by -6% as compared to a calibrated expired gas analysis system (Montgomery et al., 2009), when calculating %VO$_2$max intensities for individuals this -6% variation was accounted for. This was done by allowing the upper VO$_2$ limit to be 66% and the lower VO$_2$ limit to be 34%.

To ensure proper calibration of the stadiometer (Suhong RGZ-120, Jiangsu Suhong Medical Instruments Co., China) a standard weight was used to check the calibration of the weighing scale and a calibration rod of known and fixed length was used to check the stadiometer.

**3.11 Data Collection Techniques**

The data collection followed the following procedure.

**3.11.1 Recruitment and Training of Researchers**

Two research assistants (Exercise and Sport Science masters students) were recruited from Kenyatta University, briefed about the research and trained by the primary researcher. Their training entailed the following:

1. How to safely conduct an exercise training session with HR monitoring.
2. How to accurately measure anthropometric data (height, weight, hip and waist circumferences) of individuals.
3. Basic physiology of BP and the different BP management methods.
Two nurses were recruited from the Kenyatta University Health Clinic to measure the BP manually using the mercury sphygmomanometer (Rudolf Reister GmbH, Bruckstr, Jungingen Germany).

3.11.2 Subject Recruitment

At Kenyatta University and Thika Level 5 hospital subjects were recruited through a free BP screening day. A BP monitoring station was set up at an area of high foot traffic. Individuals were offered free BP testing (Omron, Comfort M3, Hoofddorp, Netherlands) and those with high BP were offered flyers (APPENDIX C) that outlined the dangers of elevated BP and management methods (medical and lifestyle). Individual BP readings and contacts details were recorded. Individuals who satisfied the preliminary inclusion criteria were contacted and a second round of BP testing was done to verify the BP reading using the mercury sphygmomanometer. Individuals whose BP was within the range of the target measures during the second round were then recruited to the study.

A total of 70 subjects were recruited from Kenyatta University and Thika Level 5 Hospital. Individuals who did not achieve a minimum of 80% compliance with exercise or did not collect their Mg supplements consistently at the beginning of the week were excluded at the end of the study. 8 participants from the EX group, 9 from the EMG group, and 6 from the MGS group data were not included in the study because they did not achieve the minimum compliance rate.

3.11.3 Medical/Health Screening

Subjects were then required to fill in a Medical Screening Questionnaire (designed by primary researcher) (APPENDIX B) which was used to determine whether they
completely satisfied the inclusion criteria. This questionnaire was administered by a Nurse. Systematic sampling was used to allocate the individuals to one of the three specific groups.

This was done by allocating the first individual to the EX group, the second individual to the MGS group and the third individual to the EMG group according to how they presented themselves during the baseline test at either Kenyatta University or Thika Level 5 hospital. This sequence was repeated for the entire sample.

3.11.4 Exercise Familiarization.

Subjects who were assigned to the EX and EMG group were invited 7 days prior to the baseline tests for exercise familiarization. This reduced the risk of musculoskeletal injuries and ensured effective exercise procedures and practices (Fletcher et al., 2001). They were first and foremost introduced to the safety and precautionary measures that they should take when exercising by the researchers. All the exercises were explained in detail. Proper technique was demonstrated and each subject had a chance to attempt the exercises, during which the researcher also gave feedback and made correction in technique. All subjects were taken through proper placement of heart rate monitors. They underwent a simulated training session in which their heart rate intensities were maintained at 40≤60% of $\text{VO}_2\text{max}$ so that they could have a feel of what the training sessions and intensity would be like.

3.11.5 Baseline Tests: BP, RHR and Anthropometric Data.

Once the subjects arrived at the Human Performance Laboratory at Kenyatta University or an allocated room at Thika Level 5 hospital, the time of day was recorded so as to ensure that the mid-points and post intervention tests were done during the same time of day to reduce BP confounding effects on the autonomic
nervous system emerging from daily activity patterns and diurnal influences. After 5 minutes of solitary silent rest, resting heart rates were taken immediately using the heart rate monitors followed by resting BP which was taken on the left arm.

Subjects were instructed to sit on a chair with their backs straight, their arms supported at heart level, with no tight clothing constricting the arm and feet planted flat on the floor. BP was taken by a nurse. To enhance the reliability of the test an average of 3 measurements were taken with 2 minutes of rest in between each reading. Participants had been asked to refrain from taking coffee, strong tea or cocoa 12 hours prior to the test.

Height, weight, waist and hip circumferences were measured by the research assistants. The height, waist and hip circumference were measured to the nearest 0.1 cm while weight measurements were measured with an accuracy of 0.1 kg (average of 2 measurements).

3.11.6 6 Week Intervention

The subjects taking the Mg supplements collected their supplements at the beginning of each week from their respective locations and their BP measurements taken using the digital sphygmomanometer. This ensured that there was ample contact time with the researchers thus enhancing their (participants’) supplementation compliance. Individuals who did not collect their supplements at the beginning of the week for any reason were not allowed to proceed with the study (6 subjects). The primary researcher monitored for adverse effects of magnesium supplementation on a day to day basis where subjects provided feedback on how they were feeling. There was only one (1) individual who complained of gastrointestinal distress and had to be removed from the study.
The individuals in the EMG and EX groups were required to visit Kenyatta University and Thika Level 5 hospital five times a week for their exercise program (Monday to Friday, 45 minutes per session). During each training session (APPENDIX D) the subjects exercise intensities (40≤60% of VO₂ max) were monitored using a HR monitoring system (Garmin, Olathe, Kansas, US). This is within the guidelines provided by ACSM (2015) for exercise prescription for individuals with hypertension. The frequency was preferably on most days of the week (minimum 4 days a week). The intensity was moderate (40-<60% VO₂ max) and time ≥30 min of continuous or accumulated physical activity. If participants fell below or above the targeted recommended intensities, the individual participants exercise intensities were decreased or increased so as to achieve the relevant intensity. Subjects were requested to avoid exercise outside the research and were required to attend a minimum of 80% of sessions. The data for subjects who failed to do so at the end of the study was not included (10 subjects).

3.11.7 Mid-Point and Post-Intervention Tests.

After three (3) weeks BP and RHR were taken 48 hours after their most recent exercise session while the post intervention test readings were taken 48 hours after their last exercise session so as to get true chronic values while at the same time reducing the influence of post exercise hypotension. Those tests were conducted at the same time of day as the baseline tests to enhance reliability. The protocol during the baseline, mid-point and post intervention tests remained the same. Anthropometric data was also recorded and all data captured on the data collection sheet.
3.12 Data Analysis and Presentation

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 within the groups while a Two-way ANOVA was used to compare mean differences from baseline, mid-point and post-test between the groups.

If the difference between pretest and posttest were statistically significant, the Bonferroni post-hoc test was used for pairwise comparisons. A linear regression analysis was used to detect associations between BP and RHR.

3.13 Logistics and Ethical Considerations

The researcher applied and got approval from the Kenyatta University Graduate school (APPENDIX E), Kenyatta University Ethical review committee (KU-ERC) (APPENDIX F), National Commission for Science, Technology and Innovation (NACOSTI) (APPENDIX G), Nairobi Education (APPENDIX H), Health (APPENDIX I) and County Commissioner (APPENDIX J) and Kiambu County’s Education (APPENDIX K), Health (APPENDIX L) and County Commissioner (APPENDIX M), Kenyatta University grounds (APPENDIX N) and Thika Level 5 hospital before commencing the study (APPENDIX O).

The initial study title was, “Effect of exercise and magnesium supplementation on blood pressure and blood coagulation on hypertensive adults in Nairobi and Kiambu counties, Kenya.” This was later amended to, “Effect of exercise and magnesium
supplementation on blood pressure on hypertensive adults in Nairobi and Kiambu counties, Kenya.” The amendment was due to damage to the thromboelastography machine, which was approved by KU-ERC (APPENDIX F.2). The final title of the study became, “Effect of exercise and magnesium on blood pressure and heart rate on hypertensive adults in Nairobi and Kiambu counties, Kenya.” This was after the defense at the Kenyatta University Graduate School where the researcher was asked to include the term, heart rate in the title due to the fact that it was heavily investigated.

Participants were provided with an informed consent form that they signed before they participated in the study (APPENDIX A.1 & A.2).

The primary researcher verbally went through all the details of the entire study with the subjects prior to the subjects signing the document. All hard copy documents containing study subjects information were securely locked in a cabinet within the primary researcher’s house, with no one else having access. All soft copy data being kept on the primary researcher’s laptop are password protected. All names were anonymized and codes were used.
CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

4.1 Introduction

This chapter presents the results of the current study in the order outlined in the objectives of the study:

1. To report on the change in anthropometrics after 6 weeks of exercise, Mg or combination of exercise and Mg.
2. To report on the change in resting BP following a 6 week exercise regimen in grade I hypertensive adults.
3. To report on the change in resting BP following a 6 week Mg supplementation regimen in grade I hypertensive adults.
4. To report on the change in resting BP after a 6 week combined exercise and Mg supplementation regimen in grade I hypertensive adults.
5. To compare the effects on resting BP between the 3 groups after 6 weeks of exercise, Mg supplementation or a combination of both exercise and Mg
6. To compare the relationship between RHR and BP.
7. To report on the change in resting HR after a 6 week exercise regimen in grade I hypertensive adults.
8. To report on the change in resting HR after a 6 week Mg supplementation regimen in grade I hypertensive adults.
9. To report on the change in resting HR after a 6 week combined exercise and Mg supplementation regimen in grade I hypertensive adults.
10. To compare the effects on resting HR between the 3 groups after 6 weeks of exercise, Mg supplementation or combination of both exercise and Mg.
4.2 Participants Characteristics and Anthropometrics

The characteristics and anthropometrics of the studied groups are presented in Table 4.1.

**Table 4.1: Groups’ characteristics and anthropometrics before and after 6 weeks of exercise, magnesium or combination of exercise and magnesium.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Study Group</th>
<th>EX (n=15)</th>
<th>MG (n=18)</th>
<th>EMG (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Post-test</td>
<td>Baseline</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td>7 Males</td>
<td>8 females</td>
<td>9 Males</td>
</tr>
<tr>
<td>Age (y)</td>
<td></td>
<td>44±9.4</td>
<td>44±7.9</td>
<td>41±7.2</td>
</tr>
<tr>
<td>Height (m)</td>
<td></td>
<td>1.6±8.0</td>
<td>1.67±7.0</td>
<td>1.71±6.1</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td></td>
<td>81.0±11.7</td>
<td>77.9±10.3</td>
<td>72.4±11.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td>29.0±3.2</td>
<td>28.0±2.9</td>
<td>25.7±4.0</td>
</tr>
<tr>
<td>WC (cm)</td>
<td></td>
<td>98.8±7.6</td>
<td>95.2±7.6</td>
<td>93.1±9.6</td>
</tr>
<tr>
<td>HC (m)</td>
<td></td>
<td>105.1±6.8</td>
<td>102.1±6.4</td>
<td>103.9±9.8</td>
</tr>
<tr>
<td>WHR</td>
<td></td>
<td>0.94±0.05</td>
<td>0.93±0.05</td>
<td>0.90±0.06</td>
</tr>
</tbody>
</table>

Values are presented as means ± standard deviations of the mean (SD).

BMI, Body mass index; HC, Hip Circumference; WC, Waist circumference; WHR, Waist to Hip Ratio. p≤0.05.

The mean age of the subjects recruited was 43 ± 8.2 years (30-57), while the mean age among the genders was 40 ± 6.6 years and 46.3 ± 8.3 years for males and females respectively. When placed in the 3 groups the mean ages was 44 ± 9.4 years, 44 ± 7.9
years and 41 ± 7.2 years for the EX, MGS and EMG groups respectively. The differences in age between the 3 groups was not significant p>0.05.

There was no significant difference observed between the three groups at baseline for the anthropometric measurements. There were significant reductions (p<0.001) in mass (-3.1 ± 2.8 and -2.6 ± 1.3 kg), BMI (-1.1 ± 1.0 and -0.9 ± 0.4 kg/m²), waist circumference (-3.1 ± 1.2 and -2.2 ± 1.9 cm), hip Circumference (-2.9 ± 1.8 and -2.4 ± 1.5 cm) for the EX and EMG groups. The reduction in mass (-3.1 kg), BMI (-1.1 kg/m²), waist circumference (-3.1 cm) and hip circumference (-2.9 cm) were significantly larger in the EX group than in the EMG group. Reduction in mass (-0.9 ± 2.1 kg), BMI (-0.3 ± 0.8), waist circumference (-0.32 ± 2.3 cm) and hip circumference (-0.7 ± 1.4 cm) were not significant (p>0.05) in the MGS group. There was no significant change (p>0.05) in waist to hip ratio in either group.

4.3 Blood Pressure Response

4.3.1 Blood Pressure Response to Exercise

Changes in BP (SBP and DBP) after a 6 week exercise program are presented below in Figure 4.1.
Figure 4.1 BP changes after 6 weeks of exercise in adults with grade 1 hypertension

There was no significant difference observed at baseline for SBP and DBP within the EX group (p>0.05) between the individuals. 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 rejects 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.
4.3.2 Blood Pressure Response to Magnesium

Changes in BP (SBP and DBP) after a 6 week Mg supplementation regimen are presented below in Figure 4.2.

**Figure 4.2 BP changes after 6 weeks of magnesium supplementation in adults with grade 1 hypertension.**

There was no significant difference observed at baseline for SBP and DBP within the MGS group (p>0.05) between the individuals. The MGS group had a mean SBP and DBP of 143.2 ± 7.0 mmHg and 86.7 ± 4.6 mmHg at baseline. Following supplementation with Mg (500 mg/day) the mean SBP reduced by -1.1 ± 4.8 mmHg and mean DBP increased by +0.7 ± 6.0 mmHg respectively after 3 weeks and reduced further by -3.4 ± 2.7 mmHg for SBP and -1.0 ± 5.2 mmHg for DBP after 6 weeks. These changes were not statistically significant (p>0.05) after 3 weeks for SBP and DBP respectively, however after 6 weeks they were significant for SBP (p<0.05) but not for DBP (p>0.05).
Therefore, the study rejects the null hypothesis because there was a statistically significant (p<0.05) reduction in resting BP (SBP) following a 6 week Mg supplementation regimen in adults with grade 1 hypertension.

4.3.3 Blood Pressure Response to Combined Exercise and Magnesium

Changes in BP (SBP and DBP) after a 6 week combination of exercise and Mg supplementation regimen are presented below in Figure 4.3.

Figure 4.3 BP changes after 6 weeks of combined exercise and magnesium supplementation in adults with grade 1 hypertension.

There was no significant difference observed at baseline for SBP and DBP within the EMG group (p>0.05) between the individuals. The EMG had a mean SBP and DBP of 145.7 ± 6.4 mmHg and 88.9 ± 5.9 mmHg at baseline.
Following a combination of exercise (45 min, 5 times a week) and Mg supplementation (500 mg/day) the mean SBP and DBP reduced by -3.6 ± 3.2 mmHg and -3.4 ± 5.1 mmHg respectively after 3 weeks and reduced further by -7.1 ± 2.1 mmHg and -4.9 ± 4.4 mmHg after 6 weeks. The changes were statistically significant (p<0.05) for SBP after 3 weeks but not for DBP (p>0.05). The changes were statistically significant (p<0.05) for both SBP and DBP after 6 weeks. Therefore, the study rejects the null hypothesis because there was a statistically significant (p<0.05) reduction in resting BP (SBP and DBP) following a 6 week combined exercise and Mg regimen in adults with grade 1 hypertension.

4.3.4 Comparison of Blood Pressure Responses between the 3 Groups

A comparison on the changes in BP (SBP) between the 3 groups (EX, MGS and EMG) is presented below in Figure 4.4.

![Figure 4.4 SBP changes after 6 weeks of exercise, magnesium or combination of exercise and magnesium in adults with grade 1 hypertension](image-url)
There was no significant difference observed at baseline for SBP between the EX, MGS and EMG group (p>0.05). The EMG group was the only group to have a significant decrease in SBP at midpoint (-3.57 ± 3.2 mmHg, p<0.05) while the decrease within the EX (-2.1 ± 4.2 mmHg) and MGS (-1.1 ± 4.8 mmHg) groups were not significant (p>0.05). Pairwise comparisons (Bonferroni post-hoc) showed that the difference in the reduction of SBP in the EMG group (-7.1 ± 2.2 mmHg) was significantly (p<0.05) higher than the decrease within the EX (-4.6 ± 3.1 mmHg) and MGS (-2.3 ± 2.7 mmHg) groups respectively after 6 weeks.

The decrease in SBP within the EX group (-4.6 ± 3.1 mmHg) was also significantly higher than the decrease in MGS group (-2.3 ± 2.7 mmHg). Therefore, the study rejects the null hypothesis because there was a statistically significantly higher (p<0.05) reduction in resting BP (SBP) following a 6 week combined exercise and Mg supplementation regimen as compared to Mg or exercise alone in adults with grade 1 hypertension.

A comparison on the changes in BP (DBP) between the 3 groups (EX, MGS and EMG) is presented below in Figure 4.5
Figure 4.5 DBP changes after 6 weeks of exercise, magnesium or combination of exercise and magnesium in adults with grade 1 hypertension

There was no significant difference observed at baseline for DBP between the EX, MGS and EMG groups (p>0.05). There was no significant (p>0.05) decrease in DBP after 3 weeks for all the 3 groups.

The difference in the decrease in DBP within the EMG group (-4.9 ± 4.4 mmHg) was not significantly (p>0.05) higher than the EX group (-3.4 ± 3.9 mmHg). However the decrease within the EMG (-4.9 mmHg) and EX (-3.4 mmHg) groups were higher than that of the MGS (-1.0 ± 5.2 mmHg) when looking at inter group differences (two way ANOVA).

4.4 Relationship between Resting Heart Rate and Blood Pressure

A Pearson correlation was used to determine whether there was a relationship between the changes in BP (SBP and DBP) and RHR after 6 weeks. The results are presented below in Figure4.6
Figure 4.6 Changes in SBP vs. changes in RHR after 6 weeks of exercise, magnesium or combination of exercise and magnesium

Figure 4.6 shows there was a statistically significant (p<0.05), weak to moderate positive correlation (r=0.33) between the changes in SBP and RHR after 6 weeks. The relationship between DBP and RHR are presented below in Figure 4.7

Figure 4.7 Changes in DBP vs. changes in RHR after 6 weeks of exercise, magnesium or combination of exercise and magnesium

There was a weak positive correlation (r=0.23) between the changes in DBP and RHR after 6 weeks however it was not statistically significant (p>0.05). Linear
regression analysis was used to determine whether the change in SBP or RHR after 6 weeks was a significant predictor of the other. When the change in SBP was the independent variable and the change in RHR was the dependent variable, the $R^2$ value was equal to 0.11, which showed that 11% of the variability in RHR could be accounted for by SBP changes. The unstandardized $\beta$ value was 0.66 which shows that for every increase of 1 unit (mmHg) in SBP there was an increase in RHR (bpm) by 66% (0.1; 1.2, 95% CI). When the change in RHR was the independent variable and the change in SBP was the dependent variable, the $R^2$ value was equal to 0.11, which showed that 11% of the variability in SBP could be accounted for by RHR change. The unstandardized $\beta$ value was 0.18 which showed that for every increase in RHR by 1 unit (bpm), there was an increase in SBP (mmHg) by 18% (0.03; 0.33, 95% CI).

4.5 Heart Rate Response

4.5.1 Heart Rate Response to Exercise

Changes in RHR after a 6 week exercise program are presented below in Figure 4.8.
Figure 4.8 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) between the individuals.

The EX group had a mean RHR of 76.9 ± 12.6 bpm at baseline. Following an exercise regimen conducted for 45 minutes 5 times a week the mean 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 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.

4.5.2 Heart Rate Response to Magnesium

Changes in RHR after a 6 week magnesium supplementation regimen are presented below in Figure 4.9.
There was no significant difference observed at baseline for RHR within the MGS group (p>0.05) between the individuals. The MGS group had a mean RHR of 82.4 ± 11.1 bpm. Following supplementation with Mg (500 mg/day), the mean RHR bpm reduced by -1.7 ± 6.7 bpm after 3 weeks and reduced further by -2.9 ± 6.1 bpm after 6 weeks.

These changes in RHR were not significant (p>0.05) after 3 weeks and 6 weeks. Therefore the study accepts the null hypothesis because there was no statistically significant (p>0.05) reduction in resting RHR following a 6 week magnesium supplementation regimen in adults with grade 1 hypertension.

### 4.5.3 Heart Rate Response to Combined Exercise and Magnesium

Changes in RHR after a 6 week combination of exercise and Mg are presented below in Figure 4.10.
Figure 4.10  RHR changes after 6 weeks of combined exercise and magnesium in adults with grade 1 hypertension

There was no significant difference observed at baseline for RHR within the EMG group (p>0.05) between the individuals. The EMG group had a mean RHR of 82.2 ± 10.7 bpm at baseline.

Following a combination of exercise (45 min, 5 times a week) and Mg supplementation (500 mg/day) the mean RHR reduced by -4.8 ± 5.9 bpm after 3 weeks and reduced further by -10.9 ± 4.0 bpm after 6 weeks. The changes were statistically significant (p<0.05) after 3 weeks and 6 weeks respectively. Therefore the study rejects the null hypothesis because there was a statistically significant (p<0.05) reduction in resting RHR following a 6 week combined exercise and Mg regimen in adults with grade 1 hypertension.

4.5.4 Comparison of Heart Rate Responses between the 3 Groups

A comparison on the changes in RHR between the 3 groups (EX, MGS and EMG) is presented below in Figure 4.11.
Figure 4.11: RHR changes after 6 weeks of exercise, magnesium supplementation or combination of exercise and magnesium supplementation in adults with grade 1 hypertension

There was no significant difference observed at baseline for RHR between the EX, MGS and EMG group (p>0.05).

Pairwise comparisons (Bonferroni post-hoc) showed that the difference in the reduction in the EMG group (-4.8 ± 5.9 bpm) was not significantly (p>0.05) higher than the reduction within the EX (-3.9 ± 4.9) and MGS (-1.7 ± 6.7 bpm) groups respectively after 3 weeks. The difference in the reduction in the EMG group (-10.9 ± 4.0 bpm) was significantly (p<0.05) higher than the reduction within the EX (-6.9 ± 4.9) bpm and MGS (-2.9 ± 6.1 bpm) groups respectively after 6 weeks. The reduction in RHR within the EX group (-6.0 ± 4.9 bpm, p<0.001) was significantly higher than in the MGS group (-2.9 ± 6.1 bpm, p>0.0) after 6 weeks. Therefore, the study rejects the null hypothesis because there was a statistically significantly higher (p<0.05) reduction in RHR following a 6 week combined exercise and Mg
supplementation regimen as compared to exercise or Mg alone in adults with grade 1 hypertension
CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

This study investigated whether combining exercise and Mg would cause higher reduction in BP than exercise or Mg alone. It has previously been shown that exercise (Cornelissen et al., 2013; Huang et al., 2013) and Mg (Bain et al., 2015; Choi and Bae, 2015) independently lower BP. Two studies have shown that Mg causes a reduction in resting or recovery BP after exercise (Kass et al., 2013; Kass & Poiera, 2015). These studies however did not provide any exercise intervention and were only investigating the change in resting or recovery BP after exercise. Secondly, these studies were done on normotensive individuals while the current study focused on individuals with grade I hypertension. The current study however provided and exercise intervention, investigated chronic changed in RHR and resting BP and focused on individuals with grade I hypertension.

Findings from the current study suggest that combining exercise and Mg elicits a bigger reduction in SBP than exercise or Mg alone, with exercise having a higher influence than Mg. The combination of exercise and Mg elicited a higher reduction in DBP than Mg alone but not exercise.

5.2 Blood Pressure Response

5.2.1 Blood Pressure Response to Exercise

The current 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) and Pescatello et al. (2015) on the effects of exercise and BP.
The study by Pescatello et al. (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 BP 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 current study outlined and justified its use of the frequency intensity, time and type of exercise to ensure maximal blood pressure reductions in individuals with grade 1 hypertension.

The reviews, meta-analysis, and trials were used to update the ASCM (2004) prescription for exercise and hypertension (Pescatello et al., 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≤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 current study was governed by the prescriptions above and is presented in APPEDNIX D. However, even though all the above prescriptions have merit in terms of BP reduction, the combination of aerobic and dynamic exercise (as the case with the current 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 current study (50% VO₂ max) 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 current 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 current study, the individuals were limited and could not exert themselves past 50% VO₂ max while the subjects in the current study were able to go above 50% VO₂ max to 60% VO₂ 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 et al. (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 current study acute BP measurements were not taken. Instead, BP changes were taken at 3 weeks and the reductions (-2.1/1.1 mmHg) were not significant (p>0.05). The findings from the current study suggest that the cumulative effect of acute BP changes or PEH did not affect the chronic resting BP by 3 weeks.

These findings are similar to those of Liu et al. (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 BP, it may take 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 BP through exercise even after the effects of PEH have disappeared.

5.2.2 Blood Pressure Response to Magnesium Supplementation

The current study found a significant (p<0.05) reduction in SBP of -2.3 mmHg, but no significant (p>0.05) changes in DBP in the MGS group (figure 3).

The findings from this study are consistent with a meta-analysis by Zhang et al. (2016) on 34 trials involving 2028 participants (18-84 years), with the total duration
varying from 3 weeks to 6 months. The study reported a reduction of -2.0 mmHg in SBP which is similar to the current study.

However, the study also found a reduction in DBP of -1.78 mmHg which the current study did not find and this may have been due to the fact that the studies within the Zhang et al. (2016) meta-analysis may have had a longer duration (>3 months) and larger sample size (>100 participants).

The results from the current study are also similar to the systematic reviews and meta-analysis by Jee et al. (2002), Dickinson et al. (2006) who reported reductions in SBP of -2.2-1.0 mmHg in their systematic reviews. The findings from the studies reported small but statistically significant changes. Nonetheless, there are other studies that have reported larger reductions in BP due to Mg supplementation.

A meta-analysis by Rosanoff (2013) looked at a group of 7 studies with a uniform sub-set of 135 hypertensive subjects (SBP>155) on anti-hypertensive medication for a minimum of six months. The analysis found that the mean reduction in BP was -18.7 mmHg. The larger reduction in BP reported in the study by Rosanoff (2013) may have been due to the homogenous nature of the samples, while the smaller reductions in BP reported in the studies by Jee et al. (2002), Dickinson et al. (2006) and Zhang et al. (2016) may have been due to variation in: The population studies, type and dosage of Mg, pre-treatment BP levels, duration of the trial, dietary nutrients and minerals. These may have acted to seriously underestimate the potential of Mg in some (but not all) subjects. This fact highlights the importance of homogeneity in the sample population to ensure higher reduction in BP. The current study strived to increase homogeneity by reducing the age bracket (30-60 years), by ensuring that participants are taking same Mg dosage (500 mg/day) over the same duration of time and by restricting the subject within the study to grade I
hypertension. The major difference between the current study and that by Rosanoff (2013) was the study duration.

The study by Rosanoff (2013) only included studies conducted over durations longer than 6 months while the current study was conducted over duration of 6 weeks. The study by Zhang et al. (2016) also emphasized a time-dependent relationship with durations above 2 months required to cause large reductions in BP.

Since magnesium’s effects on BP has a time-dependent relations, studies involving Mg supplementation should be conducted over a longer duration of time so as to ensure the BP lowering effects of Mg have taken place.

However, a study conducted by Banjanin and Belojevic (2018) on 48 participants (19 men and 29 women) aged 24-65 years with essential hypertension on antihypertensive medication reported reductions of -8.9 mmHg and -5.8 mmHg for SBP and DBP respectively after 1 month of Mg oxide (300 mg/day). The reason the reduction in BP was larger than in the current study, even though the duration was shorter and the sample size was similar, was due to the fact that the study by Banjanin and Belojevic (2018) was conducted on individuals on antihypertensive medications while the current study excluded any individuals on antihypertensive medications. Mg supplements have been shown to enhance the BP lowering effects of anti-hypertensive medications (Rosanoff, 2010).

5.2.3 Blood Pressure Response to Combined Exercise and Magnesium

The current study found significant (p<0.05) reductions of -3.5 mmHg in SBP after 3 weeks and -7.1 mmHg and -4.9 mmHg in SBP and DBP respectively in the EMG group after 6 weeks.
There are two studies that investigated the effect of Mg supplementation on resting/recovery BP after exercise (Kass et al., 2013; Kass & Poiera, 2015).

The study by Kass et al. (2013) was a pilot study investigating the effect of Mg supplementation on resting and recovery SBP after aerobic or resistance exercise on normotensive individuals. The study was conducted on 16 males (19-24 years) randomly assigned to either a 300 mg/day Mg oxide supplementation group or a control group over a duration of 14 days. The subjects performed a maximal 30 minute cycle, followed by three x 5 second isometric bench press, at baseline and post-test. BP was measured before the exercise, immediately after and 5 minutes after recovery. This study demonstrated that Mg caused a reduction in SBP (-8.9 mmHg) in the Mg supplemented group, which was higher than that in the control group (-0.8 mmHg, p>0.05).

The second study by Kass and Poiera (2015) on 13 recreational runners, cyclists or triathletes (7 males and 6 females) over a 4 week duration investigated the acute effects (1 week) vs. chronic (4 week) effect of Mg supplementation on recovery BP following exercise. The mean age of the subjects in the chronic group was 40.8 and acute group was 35.8. Subjects were placed in either a 300 mg/day Mg supplement group for 1 week or 4 weeks. A 40km time trial followed by an 80 % 1RM bench press was performed to exhaustion at baseline and post-test (1 week and 4 weeks for both groups) where BP measurements were taken before and after the test. The reduction in SBP (-2 mmHg and -0.7 mmHg) within acute and chronic Mg loading groups were higher than in the control group. The DPB changes were -9 mmHg and-3 mmHg at rest and post exercise for both groups. The conclusion from these two studies was that oral Mg supplementation significantly reduced post exercise and resting BP.
The major difference between the three studies (Kass et al., 2013; Kass & Poiera, 2015) and the current study is that the two studies were looking at the effect of Mg supplementation on recovery BP after exercise without providing an exercise intervention, while the current study focused on looking at whether combining and exercise program and Mg supplementation would cause larger reductions in BP than using exercise or Mg alone. This means that the results gathered from the two studies above (Kass et al., 2013; Kass & Poiera, 2015) were as a result of the BP lowering mechanisms of Mg only and not exercise.

The second difference between the three studies (Kass et al., 2013; Kass & Poiera, 2015) and the current study is that the current study focused on individuals with grade I hypertension while the studies above focused on normotensive individuals.

The third difference is that the current study focused on chronic BP changes that have occurred even after the effects of PEH have disappeared, while two studies (Kass et al., 2013; Kass & Poiera, 2015) focused on recovery BP immediately after exercise and after 5 min, which means the effects of PEH were still current.

The results of -7.1 mmHg and -4.9 mmHg in SBP and DBP in the combined exercise and Mg group may be a first of its kind in this field of research and have added to the body of knowledge.

5.2.4 Comparison of Blood Pressure Response between the 3 groups

The reduction in SBP within the EMG group (-7.1 mmHg) were significantly (p<0.05) higher than the reduction in the EX (-4.6) group and MGS groups (-2.3 mmHg) respectively.
This result suggests that a combination of exercise and Mg is more effective in lowering SBP than Mg or exercise alone where they both have a summative effect (the addition of 4.6 mmHg from the exercise group and 2.4 mmHg from the Mg supplementation group). The mean reduction in SBP within the EX group (-4.6 ± 3.1 mmHg) was also significantly (p<0.05) higher than the mean reduction in MGS group (-2.3 ± 2.7 mmHg). This suggests that exercise is more effective at lowering SBP than Mg supplementation (500 mg/day over 6 weeks), which are similar to the results from the systematic reviews by Cornelissen and Smart (2013) and Pescatello et al. (2015) which suggest that exercise lowers BP by 3.5-11 mmHg and the reviews by Jee et al. (2002), Dickinson et al. (2006) and Zhang et al. (2016) who reported reductions in -2.2-1.0 mmHg for SBP after Mg supplementation.

In the current study the reductions in DBP in EMG (-4.9 mmHg) were not significantly (p>0.05) higher than the reductions in the EX group (-3.4 mmHg) but higher than the reductions in the MGS groups (-1.0 mmHg). Secondly, the reduction in DBP within the EX group (-3.4 mmHg) was significantly (p<0.05) higher than the reduction in the MGS group (-1.0 mmHg).

The literature (Cornelissen and Smart, 2013; Pescatello et al. (2015)) suggests that the reduction in DBP as a result of exercise are higher (2.5-6 mmHg) than the reduction brought about due to Mg supplementation (Jee et al., 2002; Dickinson et al., 2006 and Zhang et al., 2016) which ranged between -0.4 mmHg and -2 mmHg.

The reason the EMG group did not have statistically significantly (p>0.05) higher reduction in DBP than the EX may have been due to the fact that higher exercise intensities cause a higher reduction in DBP in hypertensive adults who are able to tolerate higher levels of intensities (Eicher, Maresh & Pescatello, 2009).
The individuals in the current study focused on exercising at 40-60 % VO\textsubscript{2} max and could not go above this intensity because the study was following the current guidelines by the ACSM (Pescatello et al., 2004; Pescatello et al., 2015) for BP reduction for individuals with hypertension. This suggests that individuals in the current study did not get the chance to exert themselves at higher training intensities so as to ensure that the changes in DBP were high enough to cause a significant reduction.

In the current study there was a significant reduction (-3.5 mmHg, p<0.05) in SBP at 3 weeks within the EMG group. The EX and MGS groups both did not have significant (p>0.05) reductions at midpoint. These findings suggest that the combination of exercise and Mg increases the rate at which BP reduces than when exercising or taking Mg alone.

The reason the study included a standalone exercise group and standalone Mg group is due to the fact that the extent to which BP is lowered by each method is determined by its protocol. Studies conducted on the response of Mg supplements on BP (Banjanin & Belojevic, 2018; Rosanoff, 2013) have shown the extent to which the BP lowering capabilities of Mg supplements is determined by study design, type of Mg supplement, dosage, duration of exposure, sample size, sample homogeneity and other variables.

Studies conducted on the response of exercise on BP have also shown that the extent to which the BP is lowered by exercise is determined by frequency, intensity, time and type of exercise (Pescatello et al., 2015). This allowed for the researcher in the current study to determine how effective the Mg protocol (-2.3 mmHg in SBP) and exercise protocol (4.6 mmHg in SBP) were.
The result from the current study suggests that a combination of exercise and Mg is more effective at reducing SBP than exercise or Mg alone.

5.3 Relationship between Resting Heart Rate and High Blood Pressure

There was a statistically significant (p<0.05) weak to moderate positive correlation (r=0.33) between the changes in SBP and RHR after 6 weeks. This suggests that there is a relationship between changes in SBP and RHR even though it is very moderate. There also was a weak positive correlation (r=0.23) between the changes in DBP and RHR after 6 weeks however it was not statistically significant (p>0.05). This suggests that there is no relationship between DBP and RHR. Linear regression showed that for every increase of 1 unit (mmHg) in SBP there was an increase in RHR (bpm) by 66% while for every increase in RHR by 1 unit (bpm), there was an increase in SBP (mmHg) by 18%. This suggests that change in RHR is better predicted by change in SBP. However, change in SPB can be minimally predicted by change in RHR.

A meta-analysis by Cornelissen and Fagard (2005) on 396 normotensive and hypertensive adults, with exercise interventions greater than 4 weeks investigated the effects of exercise on BP regulating mechanisms and cardiovascular risk factors. The study reported reductions in mean BP of -4.7 mmHg, RHR of -6.8 bpm, increased stroke volume of +15.5% and no change in cardiac output. These results were similar to those of the current study. However, the stroke volume and cardiac output changes were not recorded in the current study.

From these results it can be deduced that reduced BP caused an increase in stroke volume and left ventricular ejection fraction due to reduced peripheral resistance.
This increase in cardiac output may have led to a decrease in the number of beats required.

Nevertheless, this may not have been the only factor that caused the change in RHR because the R² value was equal to 0.11, which showed that 11% of the variability in RHR could be accounted for by SBP changes in this study. This therefore suggests that change in SBP was just one of the predicting factors of change in RHR and 89% of the variation in RHR could be explained by factors not current in the model.

### 5.4 Heart Rate Response

#### 5.4.1 Heart Rate Response to Exercise

The current 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 et al. (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 -5 bpm for the individuals with hypertension and -6 bpm for the normotensive individuals, which suggests that the RHR response to exercise is similar regardless of BP status.

It is important to note that in Fløtum et al. (2016) there was no limitation in exercise intensity and individuals were exercising at high exercise intensities (≥70 VO₂ max), while in the current study individuals were restricted to 40-60% of VO₂max. This suggests that higher exercise intensities do not cause a higher reduction in RHR.
But when we look at the exercise adherence levels from the study by Fløtum et al. (2016), it ranged from 0.6-2.9 sessions a week.

This is half the number of sessions compared to the current study (5 sessions a week). Fløtum et al. (2016) study concluded that several markers of health profiles can be improved by low volume exercise training if intensity is high enough. This suggests that the number of sessions 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 et al. (2016) on 67 obese but healthy women (mean age of 25) yielded similar results to the current study and that by Fløtum et al. (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 (-3.7 bpm) which suggests that the increase in intensity did not cause higher reduction in RHR. The difference between the current study and the study by Mathunjwa et al. (2016) is that the exercise program in the current study was a mixture of resistance and aerobic exercise (concurrent exercise program) while in the study by Mathunjwa et al. (2016) was primarily aerobic in nature. It would be difficult to draw conclusions from the results of both studies because the duration and intensities of the exercise program were not the same.
5.4.2 Heart Rate Response to Magnesium

There was a reduction in mean RHR (-2.9 bpm) within the MGS group however it was not statistically significant (p>0.05). There is limited literature on studies done on Mg supplementation and RHR.

The action of Mg on the cardiovascular system through improved endothelial function, vascular smooth muscle tone, myocardial excitability and blood flow in systemic and coronary circulation (Houston, 2011) would suggest that increased Mg supplementation may reduce RHR by making the cardiovascular system more efficient. We can however see a slight reduction in RHR (-2.9 bpm) even though it was not significant which is suggestive that Mg may reduce RHR but perhaps calls for further investigation.

5.4.3 Heart Rate Response to combined Exercise and Magnesium

The current study found a significant reduction in the mean RHR (-10.9 bpm) in the EMG group after 6 weeks. To the researcher’s best knowledge there is no study looking at the effects of Mg supplementation and exercise on RHR. However, there is one study that has looked at the effects of Mg on recovery and RHR after exercise. A pilot study by Kass et al. (2013) on 16 normotensive individuals investigated the relationship on the effects of Mg supplements (300 mg/day Mg oxide) on RHR (secondary outcome measure) after aerobic and resistance exercise. After the 14 week intervention there was a reduction in RHR of -6 bpm in the control group and -7 bpm in the supplemented group. In this study however there was no exercise protocol prescribed and rather the exercise was used at baseline and post-test suggesting that the enhanced RHR lowering effects was due to Mg alone. The study however, did not look at changes in chronic RHR, but rather changes in recovery
heart rate 5 minutes after the exercise so it would be difficult to make comparisons based on the results.

The results from the study suggest that a combination of exercise and Mg is an effective method of reducing RHR.

5.4.4 Comparison of Resting Heart Rate Response between the 3 groups

The reduction in RHR within the EMG group (-10.9 bpm) was significantly higher than the reduction in the EX (-6.0 bpm) and MGS (-2.9 bpm) groups respectively. This suggests that a combination of exercise and Mg is more effective at lowering RHR than exercise or Mg alone. The reduction in RHR within the EX (-6.0 bpm) group was significantly higher than the reduction in the MGS (-2.9 bpm) group. This suggests that exercise is more effective in lowering RHR than Mg.

Since there was no reduction in RHR within the Mg only group but there was a large reduction in RHR within the combination of exercise and Mg group, it likely suggests that the influence that Mg had on RHR may have been due to improved exercise tolerance and performance as seen by Mohammadi et al. (2018) and Veronese et al., (2014) rather than a direct effect on the cardiovascular system, even though Mg has been shown to improve left ventricular function (Houston 2011).

Exercise controls Mg usage and distribution while Mg participates in cardiorespiratory function and strength activities, indicating that there is a reciprocal relationship between exercise and Mg in the body (Zhang, Xun, Wang, Mao & He, 2017). Mg is also involved in many processes that affect muscle function such as oxygen uptake electrolyte balance, energy production (Maria et al., 2014). Exercise has been shown to redistribute Mg within the body to accommodate for increased metabolic demands.
A study by Mohammadi et al. (2018) on 16 active college-aged males investigated the effect of Mg supplement on EMG indices of muscle fatigue followed by acute anaerobic exercise. Based on the electromyography reading (root mean square and mean power frequency) it was concluded that Mg improves performance over a short duration of high intensity training like the Wingate test.

Another study by Veronese et al., (2014) on 139 healthy women (mean age 71.5) demonstrated that Mg supplementation (350 mg/day) over a 12 week period increased the physical performance of the healthy elderly women. Mg supplementation (300 mg/day) improved short physical performance battery test scored, chair standing times and 4-m walking speeds after 12 weeks.

Since it has been suggested that several markers of health profiles (such as RHR) can be improved through higher exercise intensity (Fløtum et al., 2016), it can be suggested that if Mg improved exercise tolerance, the subjects within the current study could exercise close to the maximum set intensity for the study (close to 60 % VO₂ max) for longer periods, thus being able to reduce their RHR more.

The result from the study suggests that a combination of exercise and Mg is more effective at reducing RHR than exercise or Mg alone.
CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The study was conducted on 47 participants (25 males and 25 females) with a mean age of 43 ± 8.3 years with grade 1 hypertension. The study’s primary objective was to determine the effects of a 6 week combined exercise and Mg supplementation regimen on BP in adults with grade 1 hypertension in Nairobi and Kiambu Counties. The secondary objective was to measure the participants’ RHR.

The results from this study revealed that a combination of exercise and Mg elicited a higher reduction in SBP than exercise or Mg alone. It also showed that the reduction in SBP within the exercise group was higher than the reduction within the Mg group. This suggests that a combination of exercise and Mg is more effective at reducing SBP than exercise or Mg alone after 6 weeks. It also shows that exercise is more effective at reducing BP than Mg supplements after 6 weeks. These results may be a first of its kind in this field of research and have added to the body of knowledge.

The reduction in DBP in the combined exercise and Mg group was not higher than the reduction in the exercise group. However the reductions in DBP within the MGS and EX groups were higher than those of the MGS group. This suggests that neither a combination of exercise and Mg nor exercise alone is superior in lowering DBP. However, they both cause a larger reduction is DBP that Mg alone.

The reduction in RHR in the EMG was higher than the reduction in the EX and MGS groups respectively. The reduction in RHR was higher in the EX group than the MGS group. This suggests that a combination of exercise and Mg is more effective at
reducing RHR than exercise or Mg alone. It also shows that exercise is more effective at reducing RHR than Mg supplements.

At the end of the study 19 individuals had achieved pre-hypertension status (SBP 120-139 mmHg and DBP 80-90 mmHg) (EMG; n=7, EX; n=7 and MGS; n=5) from grade 1 hypertension status.

6.2 Conclusion

The primary findings from the current study suggests that:

1. Exercise (45 min, 5 times a week) is an effective method of reducing BP (SBP and DBP) in individuals with grade I hypertension after 6 weeks. Therefore, the study rejects 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.

2. Mg supplements (500 mg/day, Mg Citrate) cause a small but significant reduction in SBP in individuals with grade I hypertension after 6 weeks. Therefore the study rejects the null hypothesis because there was a statistically significant (p<0.05) reduction in resting BP (SBP) following a 6 week Mg supplementation regimen in adults with grade 1 hypertension.

3. A combination of exercise (45 min, 5 times a week) and Mg (500 mg/day, Mg Citrate) is an effective method of reducing BP (SBP and DBP) in individuals with grade I hypertension after 6 weeks. Therefore the study rejects the null hypothesis because there was a statistically significant (p<0.05) reduction in resting BP (SBP and DBP) following a 6 week combined exercise and Mg regimen in adults with grade I hypertension.
4. A combination of exercise (45 min, 5 times a week) and Mg (500 mg/day, Mg Citrate) is a more effective method of reducing SBP than exercise or Mg alone.

5. Therefore, the study rejects the null hypothesis because there was a statistically significantly higher (p<0.05) reduction in resting BP (SBP) following a 6 week combined exercise and Mg supplementation regimen as compared to exercise or Mg alone in adults with grade 1 hypertension.

The secondary findings from the study suggest that:

1. 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.

2. A Mg supplement (500 mg/day, Mg Citrate) does not cause a significant reduction in RHR in individuals with hypertension after 6 weeks. Therefore, the study accepts the null hypothesis because there was no statistically significant (p>0.05) reduction in resting RHR following a 6 week Mg supplementation regimen in adults with grade 1 hypertension.

3. A combination of exercise (45 min, 5 times a week) and Mg (500 mg/day, Mg Citrate) 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 combined exercise and Mg regimen in adults with grade 1 hypertension.

4. A combination of exercise (45 min, 5 times a week) and Mg (500 mg/day, Mg Citrate) is a more effective method of reducing RHR than exercise or Mg alone.
Therefore, the study rejects the null hypothesis because there was a statistically significantly higher (p<0.05) reduction in RHR following a 6 week combined exercise and Mg supplementation regimen as compared to exercise or Mg alone in adults with grade 1 hypertension.

6.3 Recommendations

6.3.1 Practice and Policy

1. For studies investigating the effects of exercise and Mg on BP, strength tests and cardiorespiratory tests should be performed at baseline and at post-treatment so as to ensure that any reduction in BP is due to the direct effects of Mg and not improved exercise tolerance.

2. For any study dealing with Mg, intracellular Mg levels need to be taken before and after the study so as to ensure that conclusions drawn from the study are as a direct effect of Mg.

3. Since pre-Mg levels have also been shown to interfere with the effect of Mg supplements on BP, it is important to measure the intracellular Mg levels so as to increase the homogeneity of the sample size, so that the effects of the Mg supplements are as similar as possible.

4. Since it has been suggested that individuals with sufficient Mg levels may not benefit from a Mg supplement, research should be focused towards individuals with hypo-magnesium.

5. These findings suggest that a combination of exercise and Mg supplementation is an alternative non-pharmacological BP management method for individuals with hypertension. Therefore, exercise and Mg
supplementation could be included as part of the treatment protocol for individuals with hypertension.

### 6.3.2 Further Research

1. 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.

2. Future research could also be done on the effects of combined exercise and Mg on individuals who have higher levels of hypertension such as Grade 2 and Grade 3 to determine whether the effect is larger in view of the fact that these individuals are most likely to be sedentary and have hypo-magnesium.

3. Future studies on individuals with hypertension could investigate safe methods of increasing exercise intensities in view of the fact that increased exercise intensities have been shown to increase the amount of BP reduction. The norm is that individuals with hypertension are restricted to lower intensities.
REFERENCES


resting and recovery from aerobic and resistance exercise and systolic blood pressure. *Journal of Sports Science and Medicine, 12*, 144-150.


APPENDICES

APPENDIX A.1: INFORMED CONSENT FORM (ENGLISH)

My name is Edwin Kiptolo Boit, I am a PH.D student from Kenyatta University. I am conducting a study on “The Effects of Exercise and Magnesium Supplementation on Blood Pressure in Hypertensive Adults in Nairobi and Kiambu Counties, Kenya” The information may be useful to the Ministry of Health to improve access, quality of screening and management of the disease. You may also stop the interview at any time. The interview may add approximately half an hour to the time you wait before you receive your routine services.

(Primary researcher verbally outlines all the details of the study)

Benefits

If you participate in this study you may help us establish an effective non drug blood pressure lowering methods and reduce the risk of blood clot development for those with high blood pressure. You may also benefit from being screened for high blood pressure and risk for blood clot development. If you are found to have a problem you will be advised on the treatment.

Reward

If you agree to participate in this study there is no direct monetary reward. However, if the treatment provides the desired results (reduced blood pressure and reduced risk for blood clot formation) you will benefit from the use of magnesium and exercise in managing your blood pressure. Two months’ worth free magnesium supplements will be given to all the participants after the study in the event that it provides the desired results. Transport expenses will also be reimbursed according the current Bus fare rates within Kiambu and Nairobi counties.

Confidentiality

The interviews and examinations will be conducted in a private setting within the clinic. Your name will not be recorded on the questionnaire. The questionnaires will be kept in a locked cabinet for safe keeping at Kenyatta University. Everything will be kept private.
Contact Information

If you have any questions with regard to the study you may contact the Kenyatta University Ethical Review Committee Secretariat on chairman.kuerc@ku.ac.ke, secretary.kuerc@ku.ac.ke, secretariat.kuerc@ku.ac.ke or the research supervisor: Dr. Gitahi Theuri on 0722622854 on Dr. Gordon Ogwen. On 0725715623.

Participant’s statement

The above information regarding my participation in the study is clear to me. I have been given a chance to ask questions and my questions have been answered to my satisfaction. My participation in this study is entirely voluntary. I understand that my records will be kept private and that I can leave the study at any time. I understand that I will still get the same care and medical treatment whether I decide to leave the study or not and my decision will not change the care that I will receive from the clinic today or that I will get from any other clinic at any other time.

Name of Participant……………………………………………………………………….

Signature or Thumbprint                                                                                Date

Investigators statement

I, the undersigned, have explained to the volunteer in a language s/he understands, the procedures to be followed in the study and the risks and benefits involved

Name of Interviewer……………………………………………………………………….

Signature or Thumbprint:                                                                                      Date:

Tel: 0706807219   email: edwinboit1@gmail.com
APPENDIX A.2: FOMU YA RIDHAA (KISWAHILI)


(Mtafiti Msingi anaelezea maneno yote ya utafiti)

Faida

Kama utashiriki katika utafiti huu utatusaidia kujifunza jinsi ya kutoa ufanisi zisizo dawa, shinikizo la damu huu mlilo mbinu na kupunguza hatari ya maendeleo tone la damu. Wewe pia utafaidika na hukaguliwa shinikizo la damu na hatari kwa ajili ya maendeleo tone la damu, na kama wewe utapatikana kuwa uko na tatizo utashauriwa juu ya matibabu.

Zawadi

Kama wewe utakubali kushiriki katika utafiti huu, hautapata malipo yoyote. Hata hivyo, kama tiba hutoa matokeo yanayostahili (kupunguza shinikizo la damu na kupunguza hatari kwa tone la damu malezi) utafaidika na matumizi ya magnesium na zoezi katika kusimamia tone la damu. Magnesium bure thamani miezi mbili yata pewa washiriki wote baada ya utafiti katika tukio hilo kuwa hutoa matokeo yanayotarajiwa. Gharama za usafiri yatarudishwa kwa mujibu wa viwango ya matatu nauli ndani ya Kiambu na Nairobi kaunti.

Usiri

Mawasiliano ya habari

Kama una maswali yoyote unaweza kuwasiliana na Sekretarieti Kenyatta University kimaadili Tathmini Kamati ya chairman.kuerc@ku.ac.ke, secretary.kuerc@ku.ac.ke, secretariat.kuerc@ku.ac.ke au Dr. Gitahi Theuri kwa 0722622854 au Dr Gordon Ogweno kwa 0725715623.

Mshiriki wa habari


Jina la mshiriki ..........................................................................................................................

_________________________________________  ______________________________
Signature au thumbprint Tarehe

Kauli ya mkaguzi

Mimi, aliyetia, nimeelezea kwa waliojitolea katika lugha yenye anaelewa, taratibu za kufuatwa katika utafiti na hatari na faida kushiriki

Jina la mhoji ............................................................... ..................

_________________________________________  ______________________________
Signature au thumbprint Tarehe

Tel: 0706807219 email: edwinboit1@gmail.com
APPENDIX B: MEDICAL SCREENING QUESTIONNAIRE

This form is to be completed prior to your participation in this research project. All information entered in this form will be kept confidential and will be used to assess your health and ability to participate in this research.

Please take your time and try to answer each question as accurately as possible and review it to ensure that you have not left any question unanswered. If you have any question you will be assisted once you have completed the form.

A. PERSONAL INFORMATION

Name: __________________________           Gender: □ Male           □ Female

Date: ____________________________

Address: __________________________

Telephone Number: ________________  Date of birth: day/month/year):________

Personal physical information

Name: ____________________________ Phone:____________________________

Address: __________________________

In case of emergency who may we contact?

Name: ____________________________ Relationship:____________________

Telephone number: __________________________
B. PRE-EXISTING MEDICAL HISTORY

Have you ever been diagnosed with the following?

<table>
<thead>
<tr>
<th>S/N</th>
<th>MEDICAL PROBLEM</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Heart disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>High Blood pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Liver disease/Hepatitis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Asthma/ Lung disease /shortness of breath</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Kidney problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Epilepsy /Faints/Fits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Blood disorders (anemia, hemophilia, blood clots)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Fracture/ Joint/ ligament problems / Bone problem within the last year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Mental illness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Loss of consciousness during exercise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Diabetes (Type I &amp; II)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Eye problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Hearing problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Hospitalized within the last 2 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Others:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C. FAMILY HISTORY (BLOOD RELATION)

For part B: Has any of your blood relations (parents or siblings) ever been diagnosed with the following?

<table>
<thead>
<tr>
<th>S/N</th>
<th>MEDICAL PROBLEM</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Heart attack:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under 55 years in males</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under 60 years in females</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>High Blood pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>High Cholesterol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Stroke under the age of 50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Others:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explain the items you have checked yes:

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
D. SOCIAL HISTORY

1. Do you currently smoke or use any tobacco products?

   ☐ Yes
   ☐ No

   If you have stopped smoking:

   a) When did you quit smoking?

2. Do you currently drink alcohol?

   ☐ Yes
   ☐ No

   If yes what is your approximate intake of the following beverages

<table>
<thead>
<tr>
<th>Wine</th>
<th>Beer</th>
<th>Hard Liquor</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ None</td>
<td>☐ None</td>
<td>☐ None</td>
</tr>
<tr>
<td>☐ Occasionally</td>
<td>☐ Occasionally</td>
<td>☐ Occasionally</td>
</tr>
<tr>
<td>☐ Often</td>
<td>☐ Often</td>
<td>☐ Often</td>
</tr>
</tbody>
</table>

If often: How many days a week:

If often: How many days a week:

If often: How many days a week:
E. MEDICATION AND SUPPLEMENT USE

1. List any prescribed medication you are currently taking?

____________________________________________________________________

____________________________________________________________________

2. List any vitamins or dietary supplements you are currently taking?

____________________________________________________________________

____________________________________________________________________

3. Have you ever had a bad reaction to any medication or supplement?

Yes □  No □

If yes please specify the medicine/supplement and reaction:

____________________________________________________________________

____________________________________________________________________

PERSONAL DECLARATION

I declare that I have read and understood this questionnaire, and completed part A, B and C of this form in consultation

All of the above is complete and correct to the best of my knowledge.

_________________________  ______________________
Signature                Date
APPENDIX C: BLOOD PRESSURE FLYER

HIGH BLOOD PRESSURE

What is High Blood pressure?
High blood pressure is a common disease where blood flows through blood vessels (arteries) at higher than normal pressure.

Normal Blood pressure is: less than 120/80 mm Hg
High Blood pressure is: ≥140/90 mm Hg

Dangers of High Blood pressure:
If the blood against your artery walls is high enough it may eventually cause health problems, such as heart disease, stroke, heart failure, kidney failure, heart attack, eye damage and Aneurism

Management methods?
When you visit a doctor he will recommend both lifestyle changes and medication depending on the severity of your hypertension.

Medication
- Angiotensin-converting enzyme (ACE) inhibitors
- Angiotensin II receptor blockers (ARBs)
- Diuretics
- Beta-blockers
- Calcium channel blockers
- Alpha-blockers
- Alpha-agonists
- Renin Inhibitors
- Combination medications

Lifestyle changes
- Eating a healthier diet
- Enjoying regular physical activity
- Maintaining a healthy weight
- Managing stress
- Avoid tobacco smoke
- Comply with medication prescriptions
APPENDIX D: EXERCISE PROGRAM

Figure 8.1: Graphical depiction of the outdoor circuit training program

Program details
Training will last 45 minutes (5 min warm up, 30 min main set and 10 min cool down)
Individuals will spend 5 minutes per zone. Intensity will be maintained at 40≤60 of VO₂ max
Training will be monitored using a HR Monitor at all times. 200ml of water every 10min

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kettle bell squats</td>
<td>Interval cycling</td>
<td>Weighted Push ups</td>
<td>Skipping</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone 5</th>
<th>Zone 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tire pushes</td>
<td>Interval running</td>
</tr>
</tbody>
</table>
APPENDIX E: GRADUATE SCHOOL APPROVAL

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: kuhps@yahoo.com
dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

FROM: Dean, Graduate School
TO: Mr. Edwin E. Bolt
C/o Department of Rec, Mngt & Exer. Science
KENYATTA UNIVERSITY

DATE: 17th December, 2016
REF: H87/32697/15

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge the receipt of your revised Research Proposal entitled “Effects of Exercise and Magnesium Supplementation on Blood Pressure and Blood Coagulation in Hypertensive Adults in Narok and Kiamutu Counties, Kenya” as per recommendations raised by the Graduate School Board of 23rd November, 2016.

You may now proceed with your data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed supervision tracking forms per semester. The form has been developed to replace the progress report forms. The supervision tracking forms are available at the University’s website under Graduate School webpage downloads.

By common letter dated 12th January 2017 (Academic) is hereby requested to grant you substantive registration for the PhD degree.

REBECCA AKHOLLO
FOR: DEAN, GRADUATE SCHOOL

cc: Chairman, Department of Recreation Management & Exercise Science
Registrar (Academic) At: Mr. Likam

Supervisors:

1. Dr. Gitahi Theuri
C/o Department of Rec, Mngt & Exer. Science
KENYATTA UNIVERSITY

2. Dr. Gordon Ogweno
C/o Department of Medical Physiology
KENYATTA UNIVERSITY
Kenya University Ethics Review Committee

Fax: 8711242/8711575
Email: kuerc.chairman@ku.ac.ke
kuerc.secretary@ku.ac.ke
www.ku.ac.ke

Our Ref: KU/ERC/APP/PROV/VOL.1 (72)
Date: 15th June, 2017

Edwin Kiptole Boit
Kenyatta University
P.O. Box 43844-00100
Nairobi.

Dear Edwin,

APPLICATION PKU/631/714: “EFFECTS OF EXERCISE AND MAGNESIUM SUPPLEMENTATION ON BLOOD PRESSURE AND BLOOD COAGULATION IN HYPERTENSIVE ADULTS IN NAIROBI AND KIAMBU COUNTIES KENYA”

IDENTIFICATION OF PROTOCOL
The application before the committee is with a research project Application Number: “PKU/631/714: “Effects of Exercise and Magnesium Supplementation on Blood Pressure and Blood Coagulation in Hypertensive Adults in Nairobi and Kiambu Counties in Kenya” Received on 11th May 2017 and approved on 15th June 2017.

1. APPLICANT
   Edwin Kiptole Boit

2. SITE
   Nairobi and Kiambu Counties in Kenya

3. DECISION
   The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (Section 7.2.1.3) and the Kenyatta University Review Committee Guidelines AND APPROVED that the research may proceed for a period of ONE year from 15th June, 2017.
ADVICE/CONDITIONS
i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
ii. Serious and unexpected adverse events related to the conduct of the study are reported to this committee immediately they occur.
iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above. If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

DR. TITUS KAHIGA
CHAIRMAN ETHICS REVIEW COMMITTEE

I, (EDWIN) Kiptoto, accept the advice given and will fulfill the conditions therein.

Signature: ______________________ Dated this day of 2017.
APPENDIX F.2: KENYATTA UNIVERSITY ETHICAL REVIEW COMMITTEE APPROVAL (AMENDED PROTOCOL)

AND APPROVED that the research may proceed for a period of ONE year from 15th June, 2017.

ADVICE/CONDITIONS

You must include a Clinician in the Study and include an elaboration of Community benefits.

i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.

ii. Serious and unexpected adverse events related to the conduct of the study are reported to this committee immediately they occur.

iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.

iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above.

If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

[Signature]

Dated this day of __________ 2018.

C.c. DVC Research Innovation and Outreach
APPENDIX G: NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY
AND INNOVATION APPROVAL

Ref No: **NACOSTI/P/17/28948/15376**

Edwin Kiptole Boit
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on **“Effects of exercise and magnesium supplementation on blood pressure and blood coagulation in hypertensive adults in Nairobi and Kiambu Counties, Kenya.”** I am pleased to inform you that you have been authorized to undertake research in Nairobi and Kiambu Counties for the period ending 7th July, 2018.

You are advised to report to the County Commissioners, the County Directors of Education and the County Directors of Health Services, Nairobi and Kiambu Counties before embarking on the research project.

On completion of the research, you are expected to submit two hard copies and one soft copy in pdf of the research report/thesis to our office.

**Godfrey P. Kalerwa MSc, MBA, MKIM**
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.
THIS IS TO CERTIFY THAT:

MR. EDWIN KIPTOLO BOIT

of KENYATTA UNIVERSITY, 0-202

NAIROBI, has been permitted to conduct
research in Kiambu, Nairobi Counties

on the topic: EFFECTS OF EXERCISE
AND MAGNESIUM SUPPLEMENTATION
ON BLOOD PRESSURE AND BLOOD
COAGULATION IN HYPERTENSIVE
ADULTS IN NAIROBI AND KIAMBU
COUNTIES, KENYA

for the period ending:

7th July, 2018

Applicant's Signature

Director General
National Commission for Science,
Technology & Innovation
APPENDIX I: NAIROBI COUNTY APPROVAL-EDUCATION

Republic of Kenya
MINISTRY OF EDUCATION
STATE DEPARTMENT OF BASIC EDUCATION

Edwin Kiptolo Boit
Kenyatta University
P O Box 43844-00100
NAIROBI

RE: RESEARCH AUTHORIZATION

We are in receipt of a letter from the National Commission for Science, Technology and Innovation regarding research authorization in Nairobi County on "Effects of exercise and magnesium supplementation on blood pressure and blood coagulation in hypertensive adults in Nairobi and Kambu Counties, Kenya."

This office has no objection and authority is hereby granted for a period ending 7th July, 2018 as indicated in the request letter.

Kindly inform the Sub County Director of Education of the Sub County you intend to visit.

James Kimotho
FOR: REGIONAL COORDINATOR OF EDUCATION
NAIROBI

G.C.: Director General/CEO
National Commission for Science, Technology and Innovation
NAIROBI
Re: Research Authorization

This is to inform you that the Nairobi City County Operational Technical Working Team reviewed the documents on the study titled, "Effects of exercise and magnesium supplementation on blood pressure and blood coagulation in hypertensive adults in Nairobi County".

I am pleased to inform you that you have been authorized to undertake the study in Nairobi County.

On completion of the study, you will submit one hard copy and one copy in PDF of the research findings to our operational research technical working group.

R. K. Muli

For: County Director of Health Services

Nairobi County

CC:

All Sub County MOHs
APPENDIX K: KIAMBU COUNTY APPROVAL: EDUCATION

MINISTRY OF EDUCATION
State Department of Education

Telephone: Kiambu (office) 928-2044688
FAX NO. 928-2090048
Email: directoreducation.kiambu@yahoo.com

COUNTY DIRECTOR OF EDUCATION
KIAMBU COUNTY
P. O. Box 2300
KIAMBU

When replying please quote
KBU/CDE/HR/4/VOL.III/37

Edwin Kiptolo Bolt
Kenyatta University
P.O. Box 43844-01000
NAIROBI

24th August, 2017

RE: RESEARCH AUTHORIZATION


The above named has been authorized to carry out research on "Effects of exercise and magnesium supplementation on blood pressure and blood coagulation in hypersensitive adults in Kiambu County, Kenya" for a period ending 7th July, 2018.

Please accord him the necessary assistance.

Emil NYAGA
For: COUNTY DIRECTOR OF EDUCATION
KIAMBU COUNTY
Ref. No: KIAMBU/HRDU/AUTHO/2017/08/27/Boit EK  
Date: 27 Aug 2017

TO WHOM IT MAY CONCERN,

RE: CLEARANCE TO CONDUCT RESEARCH IN KIAMBU COUNTY

Kindly note that we have received a request by Mr. Edwin Kiptoi Boit of Kenyatta University to carry out research in Kiambu County, the research topic being on “Effects Of Exercise And Magnesium Supplementation On Blood Pressure And Blood Coagulation In Hypertensive Adults In Nairobi And Kiambu Counties, Kenya”. We have duly inspected his documents and found that he has been cleared by Kenyatta University Ethics Review Committee until 15 Jul 2017. He thus does not need any further clearance with another regulatory body in order to conduct research within the county of Kiambu.

However, it is incumbent upon the facility in which the research is being carried out to ensure that they are conversant with the remit of the study and operate in line with their institutional norms on conducting research. This note also accords him the duty to provide feedback on his research to the county at the conclusion of his research.

Dr. M. Ndiritu Ndirangu  
COUNTY HEALTH RESEARCH DEVELOPMENT UNIT  
KIAMBU COUNTY.
APPENDIX M: KIAMBU COUNTY APPROVAL - COUNTY COMMISSIONER

OFFICE OF THE PRESIDENT
MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT
COUNTY COMMISSIONER, KIAMBU

County Commissioner
Kiambu County
P.O. Box 32-01010
KIAMBU

Ref.No: ED.12/1/VOL.V/160

24th August, 2017

Edwin Kiptoito Boit
Kenyatta University
P. O. Box 43844 - 00100
NAIROBI

RE: RESEARCH AUTHORIZATION


You have been authorized to conduct research on “Effects of exercise and magnesium supplementation on blood pressure and blood coagulation in hypertensive adults in Kiambu County” Kenya. The data collection will be carried out in Kiambu County for a period ending 7th July, 2016.

You are requested to share your findings with the County Education Office upon completion of your research.

J.A RATEMO
FOR, COUNTY COMMISSIONER
KIAMBU COUNTY

Cc: County Director of Education
KIAMBU COUNTY
National Commission for Science, Technology and Innovation
P.O. Box 30423-00100
NAIROBI

The County Coordinator of Health
KIAMBU COUNTY

All Deputy County Commissioners (for information and record purposes)
KIAMBU COUNTY

"Our Youth our Future... Invest in our Peace and Substance Use Campaign"
APPENDIX N: KENYATTA UNIVERSITY GROUNDS

KENYATTA UNIVERSITY

OFFICE OF DEPUTY VICE-CHANCELLOR, RESEARCH,
INNOVATION AND OUTREACH

Re: KU/DVCR/RCR/VOL.3/236

Mr. Edwin Boit,
Dept. of Recreational Management & Exercise Science
KENYATTA UNIVERSITY

P. O. Box 43844 – 00100
Nairobi, Kenya
Tel. 254-20-810901 Ext. 026
E-mail: dvc-rio@kunect.ke

21st September, 2017

Dear Mr. Boit,

RE: REQUEST TO COLLECT RESEARCH DATA AT KENYATTA UNIVERSITY

This is in reference to your letter dated 18th September, 2017 requesting for authorization to collect research data at Kenyatta University on the topic “Effects of Exercise and Magnesium Supplementation on Blood Pressure and Blood Coagulation on Hypertensive Adults in Nairobi and Kiambu Counties” towards a PhD degree of Kenyatta University.

I am happy to inform you that the Vice-Chancellor has approved your request to collect data. It has been noted that you wish to set up 2 blood pressure monitoring booths within the premises of the main campus to enable you measure blood pressure and recruit willing participants into your study sample. Prior to doing so, kindly come over to meet with me for a discussion on how best to do this.

Yours Sincerely,

Prof. F. Q. Grovenor
Deputy Vice-Chancellor
Research, Innovation & Outreach
cc. Vice-Chancellor
Chairman, Department of Recreational Management & Exercise Science
APPENDIX O: THIKA LEVEL 5 CLEARANCE

COUNTY GOVERNMENT OF KIAMBU
DEPARTMENT OF HEALTH

APPRAVIL TO CARRY OF RESEARCH

Principal investigator: EDWIN KIPTOLO BOIT

RESEARCH TOPIC: EFFECTS OF EXERCISE AND MAGNESIUM SUPPLEMENTATION ON BLOOD PRESSURE AND BLOOD COAGULATION IN HYPERTENSIVE ADULTS IN THIKA LEVEL 5 HOSPITAL.

Following deliberations by Thika Level 5 hospital research committee, your proposal to carry out the above research at this facility has been approved. However, you will need to provide us with licence from NACOSTI before you can commence the data collection.

Take note that you are required to submit a copy of your research findings upon completion of the study to the hospital. It is also expected that the Ethical consideration and the research subjects confidentiality will be maintained as you have outlined in your proposal.

Any patient confidential information that you may access during your research should not be used without consent.

This letter is valid up to 9th March, 2018.

For any queries feel free to contact the committee chair through the Medical Superintendent’s office. Thank you and all the best.

DR. J. WANGECHI
CHAIR TRC
THIKA LEVEL 5 HOSPITAL

Date: 9th October, 2017

THIKA LEVEL 5 HOSPITAL
P.O. BOX 227
THIKA

Ref: No. MOMS/TKA VOL III (361)