LOW TO MODERATE-INTENSITY EXERCISE ON BLOOD PRESSURE RESPONSE IN HYPERTENSIVE OLDER ADULTS

by

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Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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ABSTRACT

This study aims to investigate the blood pressure response of a single bout of exercise at low to moderate intensity in older adults with normal/grade 1 hypertension. 120 physically active adults (74.80 ± 6.3 years) randomly completed two aerobic exercise sessions of 30 minutes at low (30% heart rate reserve [HRres]) and moderate (50% HRres) intensity. Blood pressure was assessed pre-exercise, immediately after, and 30 minutes after the completion of the exercise bout. Systolic and diastolic blood pressure increased after both exercise intensities without significant differences. Both exercise intensities saw a proportionate decrease in post exercise blood pressure response compared to 30 minutes after exercise. There was no statistically significant difference in post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise to low or moderate intensity. The standardized mean difference in examining the systolic changes before the intervention was 134.48 ± 17.46, 144.10 ± 18.06 immediately after, and 127.57 ± 16.4 30 minutes after exercise. The standardized mean difference in examining the diastolic changes before the intervention was 75.50 ± 11.53, 75.03 ± 9.02 immediately after, and 73.15 ± 9.9 30 minutes after exercise , respectively, where these differences were statistically significant ($P < 0.05$). In conclusion, older adults can benefit from aerobic exercise in both low and moderate intensity.

Keywords: hypertension, exercise intervention, systolic blood pressure, diastolic blood pressure, older adults

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List of Abbreviations

Aerobic exercise training (AET)

Ambulatory blood pressure (ABP)

American College of Sports Medicine (ACSM)

Analysis of covariance (ANCOVA)

Angiotensin-converting enzyme inhibitors (ACE-Inhibitor)

Angiotensin receptor blockers (ARBs)

Beta-blockers (BB)

Blood pressure measuring device (BPMD)

Body mass index (BMI)

Cardiopulmonary exercise testing (CPET)

Cardiovascular disease (CVD)

Combination training (COM)

Dietary approach to stop hypertension (DASH)

Diastolic blood pressure (DBP)

Fitness Registry and the Importance of Exercise (FRIEND)

High-intensity interval exercise (HIIE)

Hypertension (HTN)

Institutional Review Board (IRB)

Metabolic equivalent (MET)

Moderate-intensity continuous exercise (MICE)

Moderate-intensity continuous training (MICT)

Moderate to vigorous physical activity (MVPA)’

Peripheral artery disease (PAD)

Percentage of heart rate reserve (%HRR)

Physical activity (PA)

Physical Activity Readiness Questionnaire for Everyone (PAR-Q+)

Post-exercise hypotension (PEH)

Randomized controlled trial (RCT)

Stroke volume (SV)

Systolic blood pressure (SBP)

Target heart rate (THR)

World Health Organization (WHO)

CHAPTER ONE: INTRODUCTION

Need for the Study

According to updated guidelines from the 2015-2016 Nation Health and Nutrition Examination Survey (latest available version), 45.4% or 180 million individuals have been diagnosed with hypertension (HTN) in the United States (US) (Chobufo et al., 2020). Approximately 60% of the US population has likely been diagnosed with HTN by age 60, and about 65% of men and 75% of women develop high BP by 70 years (Oliveros et al., 2020). Hypertension is a modifiable risk factor that is defined as a systolic (SBP) value of 140 mm Hg or more and diastolic blood pressure (DBP) of more than 80 mm Hg (Iqbal & Jamal, 2023). The onset of hypertension drastically increases with age, which can be counteracted by preventative measures such as dietary modifications, medication compliance, and regular exercise. Older adults are at a greater risk of developing hypertension, contributing to the development of heart failure, myocardial infarction, renal failure, and stroke (Oliveros et al., 2020).

Specifically, exercise is shown to decrease systolic and diastolic BP and daytime average ambulatory BP; hence, a research study revealed that a decrease followed a 45-minute exercise in systolic, diastolic, and mean BP levels which lasted for 24h (Alpsoy, 2020). A five mmHg decrease in BP with regular exercise may be ensured. With a reduction of 5 mmHg in systolic BP, mortality due to coronary heart disease declines by 9%, mortality due to stroke declines by 14%, and all-cause mortality declines by 7% (Alpsoy, 2020). The proposed research contributes valuable insights to the health science community on the effects of hypertension control in older adults. HTN increases with age, involving patients younger than 60, indicating 27% risk and 74% risk in patients aged 80. (Oliveros et al., 2020). Older adults are classified as individuals over 65 (US Department of Health and Human Services, 2022). According to Lin et al. (2020), the number of individuals aged ≥ 65 will rise to nearly 1.6 billion in 2050, encompassing 16% of the world's populace. Studies in older adults are scarce, and there is a deficiency of studies in active hypertensive individuals (Lopes et al., 2020).

Various studies have shown that BP is significantly reduced following a single bout of exercise, depending on the exercise characteristics, i.e., frequency, intensity, time, and type (Marçal et al., 2021). A single session of high-intensity interval exercise (HIIE) is associated with a statistically significant and clinical reduction in daytime ambulatory BP compared to a single session of moderate-intensity continuous exercise (MICE). Marçal et al. (2021) report that exercise training can reduce BP up to 5-8mmHg through systolic and diastolic values. Evidence is reported that single bouts of exercise may reduce BP compared to control values (Farinatti et al., 2022). According to Farinatti et al. (2022), moderate-intensity exercise effectively lowered office BP (1-2mmHg; 30-60 minutes postexercise). The drop in BP observed after a single bout of exercise showed a solid positive association with the chronic reduction in BP observed after eight weeks of exercise training, suggesting that the acute decrease in BP may be associated with long-term adaptations to exercise (Lopes et al., 2020).

The previously mentioned studies reinforce the importance of hypertension control in elderly individuals, indicating future research recommendations. A lack of literature on hypertension control in older adults is prevalent, and this study is needed to grasp knowledge of exercise intensity and the benefits that can be acquired. Various studies have examined older individuals, but none compared exercise intensity to lower blood pressure (Bowling, Brightwell, Carpes, Di Lorito, Izquierdo, and Oliveros). Gaps within the literature on hypertension control in the elderly population are vague; therefore, examining the effects of exercise intensity on blood pressure response in older adults is imperative. Lu et al. (2022) conducted a study with middle-aged adults that showed that medium-intensity training (MIT) is best for improving hypertension patients' blood pressure. Pescatello and colleagues found a drop in BP to be more distinct in the first five hours following a 40-min bout at moderate (60% of VO2max) vs. light intensity (40% of VO2max) (Marçal et al., 2021). Lopes et al. (2020) report that systolic BP diminished after exercise in both exercise bouts, although the response differed across time; that is, the decrease in systolic BP was noteworthy instantly after the 30% protocol, and this effect lasted until 2 hours post-exercise.

Problem Statement

Oparil et al. (2018) report that suboptimal blood pressure remains the most significant risk factor conducive to the global burden of disease and global all-cause mortality, leading to 9.4 million deaths and 212 million lost healthy life years (8.5% of the worldwide total) each year. The problem to be addressed in this study is the effects of low to moderate-intensity exercise on blood pressure response in hypertensive older adults. Per the American College of Sports Medicine, the term older adult represents a diverse spectrum of ages and physiological capabilities, typically including individuals aged greater than 65 years and individuals aged 50 to 64 years with clinically significant conditions or physical limitations that affect movement, physical fitness, or physical activity (PA) (Liguori, 2022). It is problematic to differentiate the effects of aging on the regular function of the impact of deconditioning or illness (Liguori, 2022). Because of age-related decline to maximum aerobic capacity, the relative exercise intensity will usually differ when older and younger individuals work at the same level.

According to Oliveros et al. (2020), the worldwide problem of hypertension is growing due to an aging population estimated to affect one-third of the world's population by 2025. Older adults are the least active of all age groups. Only 12% of people aged greater than 65 years account for partaking in aerobic and anaerobic strengthening activities that meet federal recommendations. Fewer than 5% of individuals aged 85 and older meet the same guidelines. Few studies have examined hypertension control and single bouts of low to moderate exercise intensity in older populations (Alpsoy, Bowling, Carpes, Costa, Herrod, Kazeminia, Lopes, Oliveros, Sardeli).

According to Alpsoy (2020), BP decreases following a training session, and this decline continues for up to 24 hours, called post-exercise hypotension. The prevalence of hypertension and the occurrence of HTN-related CVD rise with older age, making BP control amongst older adults a significant population health objective (Bowling et al., 2021). According to Carpes et al. (2022), older adults with hypertension present high inter-individual blood pressure variability after a single bout of exercise. According to Costa et al. (2019), an immediate drop in BP following an aerobic training session is evidenced in clinical settings with formal supervision in hypertensive older populations. Using a random-effects model, a recent meta-analysis by Herrod et al. (2018) reported statistically significant decreases in both resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) as a result of aerobic exercise in adults with a mean age of 65 years and older. A research study has conveyed different results about the impact of exercise on BP, exercise type, duration, and frequency within a specific period, and its relationship with decreasing BP (Kazeminia et al., 2020). The reduction in BP observed after a single exercise session showed a strong positive connection with the prolonged decrease in BP observed after eight weeks of exercise training, signifying that the acute reduction in BP may be linked to long-term adaptations to exercise (Lopes et al., 2020). Oliveros et al. (2020) report hypertension in older adults is linked to unfavorable cardiovascular effects, such as heart failure, stroke, myocardial infarction, and death. As adults age, the risk of HTN increases, involving patients younger than 60, indicating 27% risk and 74% risk in patients aged 80. (Oliveros et al., 2020). There needs to be more literature on reducing hypertension in older adults, especially differences in the effects of low-intensity and high-intensity exercise. This poses an issue in the elderly population because a relationship between longevity and quality of life is seen.

Ruegsegger et al. (2018) report that lifelong exercise increases longevity and delays the onset of 40 chronic conditions/diseases. The acceptance of the value of exercise for health benefits has dissolved considerably; the absence of exercise now presents a significant public health issue. Examining low to moderate exercise intensity and reducing blood pressure in older adults will be paramount to producing factual data. According to Sardeli et al. (2021), exercise training has decreased many physiological declines and usual diseases of aging progression and reduced BP in hypertensive older adults. Producing confounding results can give medical providers the necessary information to prescribe exercise as medicine.

Purpose Statement

This study aims to investigate the blood pressure response of single bouts of exercise at low to moderate intensity in older adults. This study will examine which exercise intensity (low or moderate intensity) promotes the best hypertension response in older adults. Lopes et al. (2020) report that a few studies exist in actively hypertensive elderly adults, and this study will add to the breadth of knowledge in the field. Studies in older adults are limited, and there is a shortage of studies in active hypertensive individuals. In addition, controversial results have been described concerning BP response to the intensity of the exercise or physical fitness status of the subjects (Lopes et al., 2020). Therefore, this study aims to compare the acute effects of two aerobic exercise intensities (low and moderate) on post-exercise BP in adults with normal to high-normal BP/essential grade I hypertension and regular exercise participation. Aerobic exercise, such as low to moderate-intensity exercise, has been demonstrated to reduce blood pressure and help manage hypertension (Lopes et al., 2018). A few studies indicate that single bouts of exercise have been shown to lower BP and improve cognitive function and inhibitory control (Heath & Shukla, 2020). Single bouts of exercise have been shown to have beneficial effects of increased longevity. According to Jakicic et al. (2019), recent proof from cross-sectional and prospective cohort studies asserts that exercise of any bout duration is associated with improved health outcomes, which includes all-cause mortality. Since there is a lack of research on single bouts of exercise in older adults, this study aims to examine the effects of single bouts of exercise at low to moderate intensity in older adults. Single bouts of exercise pose many health benefits, so an experimental study is needed to examine the effects.

Significance of the Study

This study will provide valuable insights into the effects of a single bout of low and moderate exercise on short-term changes in blood pressure among elderly individuals. This experiment will allow researchers to understand the impact of low to moderate-intensity exercise on BP in older adults. Understanding and promoting specific exercise intensity helps treat HTN in older adults. Significant health advantages can be attained by performing a moderate amount of PA on most if not all, days of the week. PA of any intensity (light, moderate, or vigorous) can offer health benefits for sedentary people. Health benefits can be experienced following just a single bout of moderate-to-vigorous PA (Liguori, 2022). Many scientific studies examine mostly moderate to vigorous exercise intensity protocols. Unfortunately, gaps in the literature are prevalent and should be addressed. Despite the overall view that exercise is valuable, the suggestion around which exercise characteristics (e.g., frequency, intensity, time, and type) are most effective for older adults is unclear, which results in a gap in the literature (Di Lorito et al., 2021). Low-intensity and moderate-intensity exercise protocols are primarily absent in scientific journals; therefore, this field needs to examine low and moderate-intensity exercise. Although a global concept of exercise as medicine prevails, not all physical exercise modes (e.g., continuous aerobic or high-intensity interval training) have the same effects on diseases and physical function (Izquierdo et al., 2021).

Performing a single bout of exercise provides many benefits. Following an exercise bout, BP decreases immediately and is continued up to 24 hours after, termed post-exercise hypotension. Findings suggest that a 20-minute bout of moderate-intensity exercise may be adequate for improving post-exercise cognitive function (Sugimoto et al., 2020). Notably, there is a recent meta-analytical indication that a single bout of exercise induces significant short (≤24 h) and mid-term (up to ∼6 months) reductions in ambulatory blood pressure (ABP), respectively, among patients with hypertension (Saco-Ledo et al., 2022). Understanding the effects of blood pressure response in a single bout of exercise will be of significant value in health science.

Research Question(s)

RQ1: *What is the relationship between exercise intensity (low and moderate) and blood pressure response immediately following a single bout of exercise in adults aged 65 and older?*

RQ2: *How does exercise intensity affect systolic and diastolic BP response following an acute bout of exercise among adults aged 65 and older?*

RQ3: *What is the statistical significance of post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise?*

Hypothesis(es)

$H_0$1: *No statistically significant difference exists between the BP response of older adults 65 and older after a single bout of exercise at low intensity compared to those who exercise at moderate intensity.*

$H_0$2: *In older adults aged 65 and older, systolic and diastolic BP will decrease proportionality after a single bout of low to moderate intensity.*

$H_0$3: *There is no statistically significant difference in post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise to low or moderate intensity.*

Overview of Methodology

The proposed methodology of the study will utilize a quantitative approach and be used to delineate the blood pressure response between low intensity, moderate intensity, and placebo during a single bout of exercise in older adults. Convenience sampling will be utilized in adults aged ≥ 65 in southern Louisiana during the spring of 2024. The surrounding area is in the middle-to-upper-income suburb outside of New Orleans. Convenience sampling is a popular form of sampling. It involves whatever population is readily available to the researcher, and asking for volunteers by posting and promoting a call for participation is a form of convenience sampling (Harkiolakis, 2021). Logistically, many potential participants within the appropriate age range live near the testing site, which is easily accessible and close in proximity. The benefits of convenience sampling are the simplicity of implementation, cost, and efficiency. According to Stratton (2021), convenience sampling is when the researcher announces the study, and participants self-select if they wish to participate.

Inferential statistics will be the data analysis used in the study. According to Guetterman (2019), inferential statistics examines differences among groups and the relationships among variables, i.e., older adults, and the association between low and moderate-intensity exercise on blood pressure response. Inferential statistics is an umbrella term that uses t-test, ANCOVA, correlation, and regression. Data will be analyzed using the IBM SPSS Statistics Software. Descriptive statistics will be analyzed using measures of central tendency and are specific methods used to calculate, describe, and summarize collected research data logically, meaningfully, and efficiently. The central tendency is the three measures of the center (mean, median, or mode) (Vetter, 2017). ANCOVA will be used to examine the difference in the effects of intensity. Two-ANCOVA will be used to explore the difference in change in each BP in males and females of low and moderate intensity immediately after and over the 30-minute post-exercise period.

According to Wadhwa & Marappa-Ganeshan (2023), a t-test is a ratio that quantifies how significant the difference is between the 'means' of two groups while considering their variance or distribution. Analysis of Covariance (ANCOVA) is one of medical research's most frequently used statistical models (Kim, 2017). This data analysis method is most useful when comparing differences in variance. In correlated data, the change in the magnitude of 1 variable is associated with a change in the magnitude of another variable, either in the exact (positive correlation) or in the opposite (negative correlation) direction (Schober et al., 2018). Grant et al. (2019) report that multivariable regression models determine the association between a dependent variable (i.e., an outcome of interest) and more than one independent variable. Descriptives analyzed using measures of central tendency. ANCOVA will be used to examine the difference in the effects of intensity. Two-Way ANCOVA with repeated measures will be used to explore the difference sex and intensity change of BP over 30 minutes post-exercise.

Definition of Terms

1. *Hypertension (HTN)* - Hypertension is systolic blood pressure (SBP) values of 130 mm Hg or more and diastolic blood pressure (DBP) of more than 80 mm Hg (Iqbal & Jamal, 2023).
2. *Hypotension* - Hypotension is a decrease in systemic blood pressure below accepted low values. While no accepted standard hypotensive value exists, pressures less than 90/60 are considered hypotensive (Sharma et al., 2023).
3. *Low-intensity exercise (LIE)* – Guidelines have recommended using the metabolic equivalent of task (METs) as reference thresholds of absolute intensities (light, <3.0 METs) (Mendes et al., 2018).
4. *Moderate-intensity exercise (MIE)* - moderate-to-vigorous physical activity, which corresponds to ≥3 METs (Franklin et al., 2018).
5. *Normotensive* - starting as low as 115/75 mmHg, well within the normotensive range (Oparil et al., 2018).
6. *Older adults* - adults 65 years and older, as well as adults 50 to 64 with clinically significant functional limitations and a chronic condition (Byra, 2020).
7. *Prehypertension* - Prehypertension was defined as an office SBP of 120 to 139 mm Hg and DBP of 80 to 89 mm Hg (Fu et al., 2020).
8. *Vasodilation* - Vasodilation is the widening of blood vessels due to the relaxation of the blood vessel's muscular walls (Ramanlal & Gupta, 2023).

Limitations/Delimitations of the Study

Limitations are elements within the research study that the researcher cannot control. First, adherence to self-monitoring BP at home is considered a limitation compared to ambulatory blood pressure (ABPM). Self-monitoring BP at home relies on the participant's willingness to take their BP and fully participate in the study. On the other hand, Dadlani et al. (2019) report that ABPM is recorded every 15–30 min over 24 hours. The participant must maintain an accurate log of BP readings to maintain the study's validity. Secondly, patients on antihypertensive medications (i.e., angiotensin-converting enzyme inhibitors (ACE-Inhibitor), angiotensin receptor blockers (ARBs), beta-blockers (BB), and calcium channel blockers may inhibit appropriate BP due to the properties of the drugs. The previously mentioned drugs have a direct effect on BP, which could skew exercise response and the results in the study. Third, post-exercise BP readings may produce more significant results if given longer post-exercise recovery time. The study will be conducted by taking BP immediately after the exercise protocol and every hour after for two hours. A decrease in BP response may be exaggerated many hours after the completion of the exercise protocol. BP declines after an exercise bout, lasting up to 24 hours, called post-exercise hypotension (Alpsoy, 2020). Delimitation is a set of boundaries in the study that narrows the scope of the research, which is under the researcher's control. Delimitations of the study will have an inclusion criterion of older adults (per the ACSM definition) aged greater than 65 years and individuals aged 50 to 64 years with clinically significant conditions or physical limitations.

Assumptions

Assumptions are things that are accepted to be true. From a quantitative standpoint, the assumption that mimics my study the best is the methodological assumption. The methodological assumption asks, "What is the research process?" The methodological assumption is about why we have to believe an interpretation is precise or how we can validate an understanding (Lee, 2017). While the assumption is made that only qualified participants would join the study, there is no way to know if specific characteristics of the population necessary to the research will precisely be replicated in the sample. Considerably sized samples and a good intake process might lessen some of the insufficiencies of convenience sampling (Harkiolakis, 2021). First, a fundamental assumption is that the selected participants are appropriate for the study. Secondly, the study's sample size, which includes participants qualified to provide accurate information, is a basic assumption. It is also presumed that participants agree to give precise and truthful information.

When considering the methodological approach through investigation, one should remember that a common theme is that they all seek the truth to make sense of what we observe/sense (Harkiolakis, 2021). Even though an experiment may lead to a correct hypothesis, this does not necessarily mean it will benefit the lives of others. Harkiolakis (2021) reports that if the researcher can classify the various elements of the phenomenon with accuracy and detail enough to gauge them as specific quantities, then the data is quantitative. Thus, the methodology one will follow is quantitative. Quantitative researchers uphold objectivity by dissociating themselves from their sample population to elude interference from individual biases and opinions that could affect the sample's responses (Harkiolakis, 2021).

CHAPTER TWO: LITERATURE REVIEW

Overview

Approximately 60% of the US population has been diagnosed with HTN by age 60, and about 65% of men and 75% of women develop high BP by 70 years (Oliveros et al., 2020). Most published work focuses on specific exercise intensities, low-intensity, steady-state benefits, and high-intensity interval training (Atakan et al., 2021). According to updated guidelines from the 2015-2016 Nation Health and Nutrition Examination Survey (latest available version), 45.4% or 180 million individuals have been diagnosed with hypertension (HTN) in the United States (US) (Chobufo et al., 2020). Hypertension is a modifiable risk factor that is defined as a systolic (SBP) value of 140 mm Hg or more and diastolic blood pressure (DBP) of more than 80 mm Hg (Iqbal & Jamal, 2023). A limited body of knowledge exists regarding the older population's single bouts of exercise and blood pressure response. This literature review summarizes the most effective exercise intensity protocols during a single exercise bout to produce the best BP response in older adults. The search strategy for this study started with establishing the literature review components outlined, which guided the keywords used in the search databases. Keywords included but were not limited to *intensity, exercise, geriatric, blood pressure,* and *hypertension.* The PubMed, EBSCOhost, and SAGE databases were searched. Sources of information included dissertations, peer-reviewed journals, and books written in English published within the last five years.

Oliveros et al. (2020) report hypertension in older adults is linked to unfavorable cardiovascular effects, such as heart failure, stroke, myocardial infarction, and death. As adults age, the risk of HTN increases, involving patients younger than 60, indicating 27% risk and 74% risk in patients aged 80. (Oliveros et al., 2020). Hypertension is a controllable risk factor and can be prevented with lifestyle modifications such as diet and exercise. Most scientific literature studies the effects of reducing hypertension with exercise, but there is limited literature on decreasing hypertension with a single exercise bout in older adults. Lopes et al. (2020) report that a few studies exist in actively hypertensive elderly adults, and this study will add to the breadth of knowledge in the field. According to Lopes et al. (2018), the importance of physical activity and exercise training as part of a comprehensive lifestyle modification to reduce blood pressure in adults with hypertension is widely acknowledged in international guidelines.

Related Literature

According to Mills et al. (2020), hypertension is the leading cause of cardiovascular disease and premature death worldwide. Given the detrimental effects that HTN poses, it is essential to investigate the BP response in a single bout of exercise in the older population. Older adults are at a greater risk of developing hypertension, contributing to the development of heart failure, myocardial infarction, renal failure, and stroke (Oliveros et al., 2020). This area of research has been neglected until recently, as most studies focus on moderate to vigorous physical activity (MVPA) in young, healthy adults. Izquierdo et al. (2021) report that physical exercise as a therapeutic technique to inhibit and treat disease and loss of functional capacity has frequently been supported by scientific and medical associations and the World Health Organization (WHO). The reduction in BP observed after a single exercise session showed a strong positive connection with the prolonged decrease in BP observed after eight weeks of exercise training, signifying that the acute reduction in BP may be linked to long-term adaptations to exercise (Lopes et al., 2020).

The study under review has unique qualities that set it apart from other studies examining BP response in older adults. This study stands out because it will examine additional covariates during the experiment (i.e., age, sex, smoking status, current exercise status, and medications) compared to less thorough experimental designs. Considering these covariates adds a more precise cause-and-effect relationship of BP response in older adults. Differentiating the work of other scholars is of the utmost importance to stand out in the field of Health Science. According to Kazeminia (2020), the impact of aerobic exercises on hypertension has mostly been tested in long-term exercise programs (at least three months) with high intensity and a high number of sessions per week (5 days/week). Assorted research studies have reported varying results about the impact of BP and exercise, considering the type of exercise, its conditions, duration, and frequency within a specific period, and its relationship with blood pressure reduction (Kazeminia et al., 2020).

The study under review will examine the BP after an acute bout of low or moderate-intensity exercise compared to a study by Ferrier et al., which showed resistance against a short aerobic exercise program in which no reduction was found in patients' blood pressure. Aerobic short-term and long-term exercise programs with mild and moderate intensities on cardiovascular indicators of older adults indicated that the short-term program had no impact on reducing systolic blood pressure, but it decreased diastolic blood pressure (Kazeminia et al., 2020). The long-term program diminished mean systolic and diastolic blood pressure from 136 to 129 and 87 to 83, respectively. Also, the mild and moderate intensity programs influenced blood pressure reduction. In the research by Westhoff et al., the impact of moderate-intensity long-term exercise programs was tested on patients with hypertension. The results showed blood pressure decline in the samples, though it was not statistically significant. Various studies have examined BP response in long-term exercise programs, but few articulate the importance of an acute bout of exercise on BP response. Overall, the study under review is unique, and data needs to be produced on the effects of BP response after a low to moderate acute bout of exercise.

Older Adults

Per the American College of Sports Medicine, the term older adult represents a diverse spectrum of ages and physiological capabilities, typically including individuals aged greater than 65 years and individuals aged 50 to 64 years with clinically significant conditions or physical limitations that affect movement, physical fitness, or physical activity (PA) (Liguori, 2022). Like numerous conditions, HTN increases with age, with its prevalence increasing from 27% in patients younger than 60 to 74% in those older than 80 (Oliveros et al., 2020). With the rapidly aging population, the onset of HTN will continue to rise. Fortunately, the patterns of the progression of BP over time in the general population are well-documented (Suvila et al., 2020). Bourdillon and colleagues performed a research experiment that is part of the Framingham Heart Study, which examined the prevalence of hypertension in older and younger adults. According to Bourdillon et al. (2022), the occurrence of isolated systolic hypertension and systolic-diastolic hypertension rose in the older age group (i.e., >46 years) compared with the younger age group. A study by Muntner et al. (2022) revealed that the US population's mean systolic blood pressure (SBP) increases with age. Amongst US adults ≥65 years of age and after multivariable modification, normal BP was less common than elevated BP/hypertension at an older age (Muntner et al., 2022)

It is concluded that the onset of a disease in the early stages usually results in a significantly poorer diagnosis than late onset. Older patients may obtain white-coat hypertension when visiting the doctor due to increased arterial stiffness. Thus, ABPM is essential in this group of patients with elevated in-office BP readings (Oliveros et al., 2020). The prevalence of hypertension and the occurrence of HTN-related CVD rise with older age, making BP control amongst older adults a significant population health objective (Bowling et al., 2021).

Inactivity and Older Adults

Most older adults do not meet the currently suggested minutes of regular physical activity per week (Eckstrom et al., 2020). This inactivity may pose a health risk in the older population and increase the prevalence of HTN. A research study has conveyed different results about the impact of exercise on BP, exercise type, duration, and frequency within a specific period, and its relationship with decreasing BP (Kazeminia et al., 2020). A few research journals study the immediate blood pressure response in older adults after a single exercise bout. According to Lopes et al., (2020), the reduction in BP observed after a single exercise session showed a strong positive connection with the prolonged decrease in BP observed after eight weeks of exercise training, signifying that the acute reduction in BP may be linked to long-term adaptations to exercise. A decrease of 3 to 4 mmHg confirmed the importance of acute exercise as a nonpharmacological treatment of hypertension. Despite the sample and exercise features, the BP was reduced in the hours following an acute bout of exercise (Carpio-Rivera et al., 2019).

A study by Kazeminia et al. (2020) revealed that exercise leads to a significant reduction of age-induced hypertension, which can further prevent the onset of CVD and other comorbidities. The investigators found that exercise leads to a noteworthy decrease in systolic and diastolic blood pressure. Accordingly, regular exercise can be part of the action plan for elderly individuals with hypertension (Kazeminia et al., 2020). Various studies examine blood pressure response in acute bouts of exercise with the older population. Kazeminia et al. (2020) compared aerobic short-term exercise programs of mild and moderate intensities on cardiovascular indicators of older adults, indicating a reduction in diastolic blood pressure, and mild and moderate intensity programs were influential for blood pressure reduction.

Low-Intensity Exercise

Low-intensity exercise should be defined to understand its critical role in decreasing blood pressure. Low intensity refers to the exercise intensity corresponding to 1.6 to 2.9 metabolic equivalents (METs) or 30-39 %HRR. One MET is an oxygen uptake of 3.5 mL/kg/min when an adult is inactive, corresponding to an energy consumption of 1 kcal/kg per hour (Yang, 2019). Accurate maximum heart rate and workload data allow exercise intensity to be based on a percentage of peak values (i.e., %heart rate reserve). The intensity indicators that will be implemented for this study are the percentages of heart rate reserve (%HRR), and the goal is to titrate exercise intensity accordingly to achieve low to moderate intensity (Mytinger et al., 2020). To calculate the HRR, the theoretical maximum HR was calculated using the formula of Gellish: 207 bpm − (age × 0.7) (Liguori et al., 2022). After the participants had been seated for 5 minutes, resting HR was taken by counting the number of heartbeats in one minute. 30% and 50% of HRR are the target heart rate zones for low to moderate exercise intensity, using %HRR to calculate the target heart rate zone.

Significant health advantages can be attained by performing a single exercise bout on most, if not all, days of the week. Various scientific studies examine primarily moderate to vigorous exercise intensity protocols, but gaps in the literature on low to moderate intensity exercise are prevalent and should be addressed. Low-intensity exercise—which older adults with hypertension can more easily tolerate—induced an immediate BP response in active adults, and experimental results indicate that both aerobic exercise intensities (low and moderate intensity) caused a rapid decrease in systolic BP. (Lopes et al., 2020). According to Lopes et al. (2018), aerobic exercise training has been recognized as a means to reduce HTN; the blood pressure reduction observed in patients with hypertension following an aerobic exercise training program is favorable but must be established in more RCTs.

Moderate-Intensity Exercise

Moderate-intensity exercise should be defined to understand its essential role in decreasing blood pressure. Moderate-intensity exercise corresponds to 3.0 to 5.9 metabolic equivalents (METs) or 40-59 %HRR. According to Nystoriak and Bhatnagar (2018), moderate levels of exercise have been discovered to be reliably connected with a reduction of the risk of cardiovascular disease, especially in individuals over the age of 65 who present with high-normal/grade 1 HTN. Health benefits can be experienced following just a single bout of moderate-to-vigorous PA (Liguori, 2022). Acquiring data on BP response in moderate-intensity exercise will provide critical intel on the specificity of exercise intensity protocols.

Some examples of moderate-intensity exercise include brisk walking, cycling, or any activity that elevates HR. Yang (2019) reports that moderate-intensity exercise produces enough health benefits without a high risk of injury. A meta-analysis of randomized controlled interventional studies found that moderate-intensity exercise performed 3–5 times per week lowers blood pressure by an average of 3.4/2.4 mmHg (Nystoriak & Bhatnagar, 2018). Examples of moderate-intensity exercises are walking briskly, cycling, hiking, and volleyball, to name a few. Wen and Wang (2017) reported that moderate-intensive exercise was closely connected to a low prevalence of adverse CVD events and better quality of life. Aerobic exercise training (AET), such as moderate-intensity walking—is a practical intervention to battle the functional decline in an aging population (Brightwell et al., 2019).

Findings suggest that a 20-minute bout of moderate-intensity exercise may be adequate for improving post-exercise cognitive function (Sugimoto et al., 2020). Notably, there is a recent meta-analytical indication that a single bout of exercise induces significant short (≤24 h) and mid-term (up to ∼6 months) reductions in ambulatory blood pressure (ABP), respectively, among patients with hypertension (Saco-Ledo et al., 2022). After a single exercise bout, BP decreases up to a few hours after completing the exercise protocol due to the vasodilation of vessels in the body, also termed post-exercise hypotension (PEH). According to de Brito et al. (2019), PEH is a reduction in blood pressure below the values observed immediately before exercise or on a control day. Understanding the effects of blood pressure response in a single bout of exercise will be of significant value in health science. Regular exercise at a moderate intensity level results in increased longevity, reduced mortality, and reduced development of cardiovascular disease, heart attack, and HTN (Kazeminia et al., 2020). It is generally recognized that regular exercise is advantageous for cardiovascular health. Frequent exercise is strongly connected with decreased cardiovascular mortality and the risk of developing CVD. Physically active individuals have lower BP, higher insulin sensitivity, and a more favorable plasma lipoprotein profile. Exercise shows that repeated physical activity subdues atherogenesis and increases the availability of vasodilatory mediators such as nitric oxide (Nystoriak & Bhatnagar, 2018).

Blood Pressure Response on Exercise

Many benefits are linked to decreased BP after an acute bout of exercise. Ávila-Gandía et al. (2021) reported that physical exercise training programs, such as aerobic training, can reduce blood pressure in hypertensive older adults. The current guidelines for individuals over 65 recommend a BP goal of <140/90 mmHg per the 2018 ESC/ESH guidelines (Oliveros et al., 2020). A recent meta-analysis reported statistically significant reductions in both resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) in adults with a mean age of 65 years and older (Kelley & Kelley, 2018). Aerobic exercise is usually performed at a moderate intensity for 30-45 minutes through continuous training (i.e., running, cycling, swimming). Studies in patients with hypertension showed that the office and ambulatory BP (AMBP) levels declined after the cardiovascular exercise session (Alpsoy, 2020). Notably, there is a recent meta-analytical indication that a single bout of exercise induces significant short (≤24 h) and mid-term (up to ∼6 months) reductions in ambulatory blood pressure (ABP), respectively, among patients with hypertension (Saco-Ledo et al., 2022). AMBP is a continuous 24-hour blood pressure monitoring system that measures BP every 15 to 30 minutes. After 24 hours, the patient returns to the clinic; the data is downloaded and discussed with the patient and provider. A single bout of exercise has been shown to reduce 24-hour ambulatory blood pressure levels in hypertensive patients and increase the percentage of patients who have achieved target BP values (Alpsoy, 2020).

Target BP readings vary according to each patient. Still, older adults should discuss several factors with the physician, such as patient preference, comorbidity burden, clinical judgment, and life expectancy (Oliveros et al., 2020). According to Alpsoy et al. (2020), a meta-analysis of 54 randomized studies, in which approximately 2400 individuals (aged >65) were examined, found that aerobic exercise reduces systolic blood pressure by 3.84 mmHg and diastolic BP by 2.58 mmHg. Different types of physical exercise training programs, such as aerobic training, can lower blood pressure in hypertensive older adults. According to Bai et al. (2022), the blend of several exercise components comprehensively promotes the physical health of older adults. It prevents injuries caused by the imbalances between the enhancement of one component and neglect of the other. According to Costa et al. (2019), an immediate drop in BP following an aerobic training session is evidenced in clinical settings with formal supervision in hypertensive older populations. The acute exercise BP-lowering effect, called postexercise hypotension (PEH), is characterized by a drop in BP values in a postexercise period compared to preexercise and by reduced BP values in a postexercise period compared to a control condition (Costa et al., 2019).

Older Adults and Exercise Intensity

A limited body of knowledge exists on acute bouts of low to moderate-intensity exercise and blood pressure response in hypertensive older adults (Ávila-Gandía, Bowling, Brightwell, Carpes, Costa, Di Lorito, Fu, Herrod, Lopes, Wen). The drop in BP observed after a single bout of exercise showed a solid positive association with the chronic reduction in BP observed after eight weeks of exercise training, suggesting that the acute decrease in BP may be associated with long-term adaptations to exercise (Lopes et al., 2020). Experiments have indicated different outcomes regarding the impact of exercise on blood pressure (i.e., considering the type of exercise, its conditions, duration, and frequency within a specific period, and its relationship with blood pressure reduction) (Kazeminia et al., 2020). A review of 27 randomized controlled trials, a total of 1,480 participants, expanded on the effects of aerobic exercise for lowering blood pressure in participants with hypertension and observed a mean reduction of 10.8/4.7 mmHg for SBP/DBP (Lopes et al., 2018). According to Nayor et al. (2023), exercise on a cycle ergometer, which all participants performed, has been formally proven to lead to higher excursions in SBP and lower peak VO_2 values compared with other forms of exercise (e.g., treadmill).

Since HR is linearly related during aerobic exercise involving large muscle groups, a predetermined training or target heart rate (THR) has become widely employed as an index of exercise intensity. HR reserve (HRR) method in which THR = (maximal HR – resting HR) x 60% to 80% + resting HR (Franklin et al., 2022). During the experimental exercise protocol, many examined moderate to vigorous exercise intensity (60-80 %HRR or 60–80% VO2 max). According to Taylor et al. (2021), numerous studies investigating all-cause mortality in elderly populations have confirmed that higher-intensity exercise may result in more significant health benefits than low or moderate-intensity exercise. Furthermore, the benefits of high-intensity exercise can be achieved substantially less than those of moderate-intensity continuous training (MICT). Using a random-effects model, a recent meta-analysis by Herrod et al. (2018) reported statistically significant decreases in both resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) as a result of aerobic exercise in adults with a mean age of 65 years and older. Lopes et al. (2020) report that their experimental results indicate that both aerobic exercise intensities (Low and moderate intensity) induced an immediate decrease in systolic BP. Even low-intensity exercise—which can be more easily tolerated by older adults with hypertension—caused an instant benefit in active adults.

Exercise Modalities

Deciding which exercise modality to use in an experimental research study is paramount. The modality must be safe, reliable, and practical to ensure the experiment goes according to plan without fault. Some studies examine BP response through interventions such as aerobic exercise training, dynamic resistance exercise training, or combined aerobic and dynamic resistance exercise training, with limited studies reporting isometric exercise training or alternative lifestyle strategies (Herrod et al., 2018). According to Herrod et al. (2018), aerobic exercise training, dynamic resistance exercise training, COM, and isometric exercise training all produced noteworthy decreases in both SBP and DBP, with no additional benefit of COM compared with single-modality exercise training and the best available evidence suggests that nonpharmacological lifestyle interventions involving aerobic, resistance training or a combination of the two can lead to statistically significant reductions in both SBP and DBP in older adults.

Pedralli et al. (2020) performed a study that incorporated participants performing exercise tests on a treadmill following the Bruce protocol. The present study's main finding is that different exercise training modalities produced similar and consistent improvement in endothelium-dependent vasodilation as measured by flow-mediated dilation, which can reduce BP (Pedralli et al., 2020). This randomized control trial (RCT) showed reductions in blood pressure in individuals with prehypertension or hypertension after eight weeks of twice-a-week moderate-intensity exercises such as treadmill and cycle ergometer. Furthermore, blood pressure reductions in response to physical training appear similar to those obtained with first-line antihypertensive drugs (Pedralli et al., 2020). The BP findings also suggest that the different types of exercises seem to positively influence BP values during the day and with no alteration at night. The reduction in SBP levels in individuals with prehypertension or hypertension (AT 5.1 mmHg and RT 4.0 mmHg) is also a significant finding within the expected range of BP reductions (Pedralli et al., 2020).

Gaps in Exercise Literature

Exercise has been shown to decrease the post-exercise BP response, but contradictory conclusions remain regarding the reaction (Carpio-Rivera et al., 2019). High-intensity exercise training has been mainly studied with long-term adaptions on hypertension response in older adults. Increasing the number of weekly exercise sessions of low to moderate exercise intensity has been studied. There is a consensus on the contradictory answers to questions about varying exercise intensities on older adults' blood pressure response. Various research studies have reported different results about the impact of exercise on blood pressure, considering the type of exercise, its conditions, duration, and frequency within a specific period, and its relationship with blood pressure (Kazeminia et al., 2020). According to Lopes et al. (2018), aerobic exercise training has been recognized as a means to reduce HTN; the blood pressure reduction observed in patients with hypertension following an aerobic exercise training program is favorable but must be established in more RCTs. Most experimental research studies examine the long-term adaptations of BP after a 4-12-week exercise program. A study by Lopes et al. (2018) reports there is an agreement that aerobic exercise training reduces SBP and DBP of hypertensive patients; a meta-analysis of RCTs lasting ≥4 weeks determined that aerobic exercise considerably reduces office SBP (−8.3 [range −10.7 to −6.0] mmHg) and DBP (−5.2 [range −6.9 to −3.4] mmHg) in hypertensive patients.

Since a limited body exists on exercise intensity and blood pressure response in the older population, it is imperative to perform a study on this subject to add knowledge in the field. Few studies have examined the BP response in older individuals since most studies involve healthy subjects. Other studies examine different exercise parameters such as frequency, intensity, time, and type of exercise. Adding to the research on BP in the older population is essential because there is a rise in the number of older adults in the US. According to Oliveros et al. (2020), the worldwide problem of hypertension is growing due to an aging population estimated to affect one-third of the world's population by 2025. Older adults are the least active of all age groups. Only 12% of people aged greater than 65 years account for partaking in aerobic and anaerobic strengthening activities that meet federal recommendations.

According to Nayor et al. (2023), over the last year, elevated BP responses to exercise have been studied concerning high ambulatory BP and incidents of hypertension. There needs to be more consensus on the definition of abnormal values in exercise BP response in clinical settings. Recently, experimental trials have been performed on maximum effort graded exercise tests (GXT). Nayor et al. (2023) report their team quantified BP responses during exercise in a large group of community-dwelling individuals (mean age 54±9) who underwent maximum-effort cardiopulmonary exercise testing (CPET). The study involved using men and women as experimental research participants. Given prospective variances among men and women in the epidemiology, physiology, and clinical implications of BP regulation, the researchers evaluated sex differences in exercise BP and its physiological correlates (Nayor et al., 2023). Examining BP response after a single bout of exercise in men and women will favorably showcase the gender differences in this phenomenon.

Males vs. Females

In the US population, gender differences in the occurrence of HTN have been reported, with a higher percentage of men than women meeting the classification for HTN. However, after age 65 years, the onset of hypertension is higher among women than men (Bowling et al., 2021). The inclusion of females in research is increasing, and researchers are becoming more definite in precisely reporting gender and sex. To further the understanding of gender and sex-specific differences in health science, researchers are encouraged to classify whether the sample includes men and women or males and females. Seals et al. (2019) report regular cardiovascular exercise is the most evidence-based approach for reducing CVD risk with aging in men and women. When participants are organized either through sex or gender, the statistical process that was used to reveal differences should be identified with statistical power and effect size (Devries & Jakobi, 2021).

The treadmill stress test is the most widely used to assess cardiorespiratory function. Sabbahi et al. (2018) performed a study on a total of 2917 maximal treadmill cardiopulmonary exercise testing responses from seemingly healthy men and women (aged 20–79 years) without cardiovascular disease were submitted to FRIEND (Fitness Registry and the Importance of Exercise: A National Database). The finding revealed that the change in resting BP is similar in men and women; slight differences exist between the two sexes. Women typically start with lower BP values that ultimately catch up to those of men by their 60s and eventually surpass measurements in men after that (Sabbahi et al., 2018). It is essential to note unmodifiable variables in the research study, such as gender differences. Examining the differences in gender after a single bout of exercise will exude a broader array of results. Lopes et al. (2020) performed a study in which both genders (male and female) were included because the temporary reduction in blood pressure after exercise does not appear to be affected by gender. Lopes et al. (2020) report there was a noteworthy effect of time in SBP ($P = .034$) and an interface between time and exercise state ($P = .026$). Significant variances were seen across time ($P = .039$), but there was no interaction between time and exercise sessions in diastolic BP ($P = .607$).

Examining the post-exercise blood pressure response in males compared to females will be of utmost importance to solidify gender-related differences in exercise intensity. According to Bassareo and Crisafulli (2020), several gender-related physiological and morphological differences exist in human cardiovascular alterations and adaptations to aerobic exercise. Females seem to have reduced vasoconstriction and lower vascular resistance compared to males, especially after exercise, and significant differences exist in the cardiovascular adaptations to physical training, with trained women showing smaller cardiac volume and wall thickness than male athletes. (Bassareo & Crisafulli, 2020). The scientific literature regarding sex-related differences in blood pressure response during and after exercise is scarce. Males have higher SBP during exercise than females due to females' dulled sympathetic response and higher vasodilatory state of women compared to men (Bassareo & Crisafulli, 2020). Gender-related differences in SBP during exercise disappeared when adjusting for BMI, exercise duration, resting SBP, and a further potential gender-related hemodynamic difference do women reach a lower maximum stroke volume (SV) during dynamic exercise compared to men (Bassareo & Crisafulli, 2020). The difference is mainly due to females' smaller cardiac size, particularly the left ventricular volume and mass, which explains the women's lower maximum CO since maximum HR does not differ between genders, as maximum HR achieved during exercise depends mainly on age rather than the subject's gender (Bassareo & Crisafulli, 2020).

Regarding hemodynamics during recovery from dynamic exercise, women have often exhibited a reduced capacity to vasoconstrict the arteriolar bed compared to men. According to Bassareo & Crisafulli (2020), the decrease in blood pressure during recovery after dynamic effort is more significant in females than males. Although the scientific literature reports conflicting results, differences between sexes in the hemodynamic adjustments during and after dynamic exercise tend to disappear when parameters are normalized by body mass and composition and when the training status is considered (Bassareo & Crisafulli, 2020).

Summary

Given the detrimental effects that HTN poses, it is essential to investigate the BP response in a single bout of exercise in the older population. Older adults are at a greater risk of developing hypertension, contributing to the development of heart failure, myocardial infarction, renal failure, and stroke (Oliveros et al., 2020). This area of research (low to moderate intensity exercise) has been neglected until recently, as most studies focus on moderate to vigorous physical activity (MVPA) in young, healthy adults. Like numerous conditions, HTN increases with age, with its prevalence increasing from 27% in patients younger than 60 to 74% in those older than 80 (Oliveros et al., 2020). With the rapidly aging population, the onset of HTN will continue to rise. Most published work focuses on specific exercise intensities, low-intensity, steady-state benefits, and high-intensity interval training (Atakan et al., 2021). A limited body of knowledge exists regarding the older population's single bouts of exercise and blood pressure response. This literature review summarizes the most effective exercise intensity protocols during a single exercise bout to produce optimal BP response in older adults.

The research perspective that will be examined is the quantitative approach, which derives from a positivist epistemology. Positivist epistemology holds that there is an objective reality that can be expressed numerically. Studies aligned with positivism generally emphasize classifying descriptive relations or causal associations through quantitative approaches, where analytically based findings from large sample sizes are favored (Park et al., 2020). This method assumes that facts based on the scientific method can make appropriately recognized assertions. This is much like the blood pressure response in exercise; as the research participant continuously exercises, a drop in systolic and diastolic pressure should be observed.

CHAPTER THREE: METHODS

Overview

Hypertension is the leading cause of cardiovascular disease and premature death worldwide (Mills et al., 2020). This study investigates the blood pressure response in single bouts of exercise at low to moderate intensity in adults aged 65 or older. Oparil et al. (2018) report that suboptimal blood pressure remains the most significant risk factor conducive to the global burden of disease and global all-cause mortality, leading to 9.4 million deaths and 212 million lost healthy life years (8.5% of the worldwide total) each year. This study will examine which exercise intensity (low or moderate intensity) promotes the best hypertension response in older adults. Therefore, this study aims to compare the acute effects of two aerobic exercise intensities (low and moderate) on post-exercise BP in adults with high-normal BP/essential grade I hypertension. Since there is a lack of research on single bouts of exercise in older adults, this study aims to examine the effects of single bouts of exercise at low to moderate intensity in older adults. Single bouts of exercise pose many health benefits, so an experimental study is needed to examine the effects.

Design

The research design that will be followed is experimental research, in which the following procedures are used: random assignment of participants to the experimental group (low intensity or moderate intensity), in which treatment is administered to the experimental group only. Experiment research uses methods initially applied in the physical and biological sciences (Joyner et al., 2018). The main difference between experimental and quasi-experimental research is that quasi-experimental research does not use a control group or random assignment.

An experimental design to promote an accurate randomized study is needed. The research study will present two groups: low-intensity and moderate-intensity. The descriptive analysis will involve a survey given to the participants, including their gender, age, race, etc. (number of participants, minimum, maximum, and standard deviation). The covariates of the study will be the participants' resting BP before exercise, age, sex, smoking status, current exercise status, and medications. Comparing and contrasting these covariates will give the study an extra dimension of validity to prove which exercise protocol is the best predictor of reducing BP. An outlier that will be examined to determine if statistical significance is present will be the current diet of the research participants. Diet plays a role in the exercise response to exercise, so it must be accounted for in the study. The survey the participants will fill out before the exercise protocol will assess the current diet they are on. The participants will be asked if they are on a dietary approach to stop hypertension (DASH) Diet or a low-sodium diet.

Research Question(s)

RQ1: What is the relationship between exercise intensity (low and moderate) and blood pressure response immediately following a single bout of exercise in adults aged 65 and older?

RQ2: How does exercise intensity affect systolic and diastolic BP response following an acute bout of exercise among adults aged 65 and older?

RQ3: What is the statistical significance of post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise?

Hypothesis(es)

$H_0$1: No statistically significant difference exists between the BP response of older adults 65 and older after a single bout of exercise at low intensity compared to those who exercise at moderate intensity.

$H_0$2: In older adults aged 65 and older, systolic and diastolic BP will decrease proportionality after a single bout of low to moderate intensity.

$H_0$33: There is no statistically significant difference in post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise to low or moderate intensity.

Participants and Setting

The participants (n = 120, mean age = 67.08) included in the study were aged ≥ 65 and located in southern Louisiana during the spring of 2024 and were assigned to one of two groups: low-intensity exercise (n = 60; 30 females and 30 males); and moderate-intensity exercise (n = 60; 30 females and 30 males). One hundred twenty older adults equate to a power of 90%, which will reduce the type 1 error. According to Serdar et al. (2021), the ideal power of a study is considered to be at least 0.8 (which can also be specified as 80%), and sufficient sample size should be maintained to obtain a Type I error as low as 0.05 or 0.01 and a power as high as 0.8 or 0.9. Both genders were included because the transient reduction in BP after exercise does not appear to be affected by gender (Lopes et al., 2020). No incentives were given to the participants for participating in the study.

The participants live in an 8-mile radius from the experiment site of Touro Infirmary, New Orleans, Louisiana. Physically active adults (men and women) aged ≥ 65 with regular participation in cardiovascular exercise training programs and normal to stage 1 hypertension were recruited from a community-based hospital. There are no foreseeable risks to this research project. A numeric code will ensure that outside individuals cannot link the forms back to participants. All informed consent sheets and questionnaires will be stored in secure cabinets. Investigators will be the only individuals with access to the data. Subjects may choose not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which they might otherwise be entitled. Results of the study may be published, but no names or identifying information will be included in the publication. The subject's identity will remain confidential unless disclosure is required by law.

The recruitment process involved soliciting face-to-face, sending emails, making phone calls, and utilizing flyers. The study subjects were not incentivized to participate in the research experiment. Randomization was used through the website "www.randomizer.org" with 4 blocks of 30 allocations. The participants were blinded to group allocations during the tests (Pedralli et al., 2020). The participants were told that the study aimed to investigate the blood pressure response of single bouts of exercise at low to moderate intensity in adults aged 65 and older. The Institutional Review Board (IRB) approved the study; written informed consent was obtained, and the Declaration of Helsinki of all procedures was conducted. Touro Infirmary (testing site) has agreed to perform the research study on-site.

The demographics for the participants were aged ≥ 65, male and female. The sample consisted of 60 males and 60 females. Exclusion criteria: changes in hypertensive medication in the preceding three months, peripheral arterial disease (PAD), lung disease, or any other contraindication to exercise. The local review board approved the study; written informed consent was obtained, and all procedures were conducted per the Declaration of Helsinki.

Instrumentation

One of the exercise protocol instruments used in this research study was a digital automated blood pressure monitor, Omron Platinum BP5450 (Omron Healthcare Co., Ltd., Kyoto, Japan). Clinically validated, automated arm-cuff blood pressure measuring devices (BPMDs) are recommended for BP measurement (Picone et al., 2023). The Omron BP5450 is a clinically validated automated BPMD that has a wide range D-ring cuff covering arm circumference range of 22–42 cm (9–17 inches) and a small D-Ring cuff for adult arm circumferences of 17–22 cm (7–9 inches)(Peprah, 2023). According to Peprah et al. (2023), the BP5450 fulfilled the standard for a general adult population and is accurate enough for home use in a general adult population according to the ISO 81060-2:2018/AMD 1:2020 protocol. Automated BPMDs eliminate most user-related errors in BP measurement standards to manual BP and are clinically validated if a scientifically accepted protocol's minimum accuracy and precision requirements are met (Picone et al., 2023).

The exercise equipment used in the study was a stationary recumbent bicycle (RBK 835; Precor Inc.). Indoor cycling (IC), or spinning, is a physical activity offered in most gyms and inpatient clinical rehabilitation settings (Chavarrias et al., 2019). Participants of varying physical fitness levels, age, and body mass indices (BMI) can cycle on a stationary bike safely and effectively. Indoor cycling on a recumbent bicycle is among the most practiced activities in wellness facilities and hospitals for most people, regardless of their physical conditioning level. Several studies have analyzed the effect of indoor cycling on several parameters related to health, such as maximal oxygen consumption, blood pressure, and body composition (Chavarrias et al., 2019). According to Chacarrias et al. (2019), indoor cycling may improve aerobic capacity, blood pressure, lipid profile, and body composition.

Regarding blood pressure and considering that HTN is a risk factor for CVD in subjects with metabolic syndrome, exercise should signify the most beneficial approach to prevent these diseases. (Chacarrias et al., 2019). According to Chacarrias et al. (2019), the benefits of IC in reducing blood pressure are higher if the duration is performed at longer intervals of time. Exercise intensity could be a determining factor in modifying the post-exercise hypotension response, so IC is a physical activity with adequate intensity since it effectively reduces arterial blood pressure (Chacarrias et al., 2019). This reduction, in healthy subjects, was observed even at the end of an IC session, where after increasing blood pressure during the session, 30 min after completion of the session, it significantly dropped concerning the initial one (−7.5%). It remains so until three hours after the end of that session (Chacarrias et al., 2019).

The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) will be utilized to ensure all participants are safe and cleared for exercise. The PAR-Q+ includes seven questions followed by additional follow-up questions to guide pre-participation recommendations. Schwartz et al. (2020) report the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) is the international gold standard for pre-participation risk stratification screening tools. This evidence-based tool was developed partly to reduce barriers to exercise and false positive readings. When people respond positively to 1 or more questions on the PAR-Q, they should consult a physician for physical activity participation clearance (Bredin et al., 2013). The entire process adhered to the international standards established by the Appraisal of Guidelines for Research and Evaluation instrument and was consistent with developing other clinical practice guidelines as this ensured that the highest standards for developing evidence-based best practices were followed for developing the new evidence-based PAR-Q+ (Bredin et al., 2013).

There are several key features to the new PAR-Q+. The current PAR-Q+ is a 4-page document containing questions to identify any possible restrictions or limitations on physical activity participation (Bredin et al., 2013). According to Thompson (2022), in 2018, the American College of Sports Medicine (ACSM) issued new guidance that has decreased the frequency of recommending medical clearance to be attained before exercise testing and program implementation. This guidance continues to be supported in the latest *ACSM's Guidelines for Exercise Testing and Prescription*, 11th edition. The PAR-Q+ screening document is necessary for all older clients because it provides guidance on which medical conditions might pose an issue during exercise and which need further evaluation, i.e., the first page of the PAR-Q+ evaluates cardiovascular and metabolic disease. If needed, subsequent pages are completed to assess further (Thompson, 2022). Using the PAR-Q+, clearance for physical activity participation is a straightforward process for a physician, exercise professional, or participant, and the entire process takes approximately 5 minutes and can be completed in the waiting area of a physician’s office (Bredin et al., 2013). The participant will answer the seven evidence-based questions on page 1 of the PAR-Q+. If the answer is no to all of the questions, they are cleared for unrestricted physical activity participation following the general physical activity guidelines for healthy asymptomatic populations (Bredin et al., 2013). If the participant answers yes to 1 or more of the questions, they must complete pages 2 and 3 of the PAR-Q+. If the participant answers no to all of the follow-up questions on pages 2 and 3 of the PAR-Q+ regarding their medical condition, they are cleared to become more physically active (Bredin et al., 2013). If the participant answers yes to 1 or more questions on pages 2 and 3, they are referred to a qualified exercise professional or the ePARmed-X+ for further probing for pertinent information (Bredin et al., 2013). At the end of the ePARmed-X+ process, the participant might be cleared for unrestricted or physical activity participation with restrictions. The participant is given a specially tailored exercise prescription to be monitored by a qualified exercise professional or is referred to a physician for additional medical probing or testing. The newly created PAR-Q+ and ePARmed-X+ tools are evidence-based and meet the requirements recognized by the medical community.

The tool uses follow-up questions to tailor better pre-exercise recommendations based on relevant medical history and symptomology (Liguori, 2022). According to Warburton et al. (2021), the new PAR-Q+ risk stratification and pre-participation strategy significantly reduced the number of individuals sent for medical referral compared to the PAR-Q (i.e., 0.8% vs. 15%, respectively). The reliability of the PAR-Q+ over three months was high (r = 0.99). The new strategy demonstrated high sensitivity (0.90 (95% CI = 0.77-0.96)) and specificity (1 (95% CI = 0.99-1)) for determining those with and without hypertension, respectively (Warburton et al. 2021). The preliminary evaluation of the new PAR-Q+ risk stratification and pre-participation strategy in comparison to the PAR-Q reveals that the new process dramatically reduces the barriers to physical activity participation, with high reliability, sensitivity, and specificity of measurement (Warburton et al., 2021). Current research trials are being conducted internationally, allowing for the continual evaluation and update of the PAR-Q+ and ePARmed-X+, and recommendations for change to this strategy are vetted through an international consensus panel to ensure that the process adheres to evidence-based best practice (Warburton et al., 2021). The forms are updated approximately every six (6) months to include new evidence-based information since this website contains the current consensus panel-approved forms for the PAR-Q+ and ePARmed-X+ (Warburton et al., 2021). The PAR-Q+ will be a valuable pre-exercise assessment tool that provides validated information from the study participants.

The study's primary investigator will keep all records and pertinent information of the participants on a password-protected computer (MacBook Pro (Retina, 15-inch, Mid 2015). An Excel spreadsheet will identify participants in number form for data security purposes, ranging from 1-120. The results will be saved in Microsoft Excel onto the password-protected computed and imported into IBM SPSS Statistics 28.0.1 (IBM Corporation).

Procedures

Each participant will complete the PAR-Q+ consent form, read detailed explanations of the procedures and protocols, and be oriented to the exercise equipment. After completing the consent form, past medical history, height and weight, medication, resting office BP, and resting heart rate will be taken (Williams et al., 2018). Each participant will read the exercise protocol instructions verbatim by the researcher to ensure the reliability and validity of the study. The participants will complete one randomly assigned exercise session of either a low-intensity (30% of HRres) or moderate-intensity (50% of HRres) exercise. Each participant will complete one randomly assigned exercise bout on the Precor recumbent bike (aerobic exercise at 30% or 50% of the heart rate reserve (HRres). Each exercise session will last 30 minutes, with 5 minutes of a warm-up, 20 minutes of aerobic exercise on a recumbent bike (either low-intensity or moderate-intensity), and 5 minutes of a cooldown.

Blood pressure will be assessed with the participants seated using an Omron Platinum BP5450 (Omron Healthcare Co., Ltd., Kyoto, Japan) automated blood pressure cuff. One blood pressure measurement will be taken at each time point: before exercise, immediately after the exercise session, and then 30 minutes after the completion of the exercise session. Subjects will be recommended to perform daily activities and maintain a regular diet. Measurements will be taken in the right arm, relaxed and at the heart level. One measurement will be recorded for the pre-blood pressure reading, one for the post-exercise blood pressure reading, and the last BP reading will be performed 30 minutes after the completion of the exercise protocol. All participants will be asked to avoid strenuous exercise activities 24 hours before the experiment and to have a light lunch, without any stimulants, no less than 3 hours before the exercise session. All subjects will remain on the same hypertensive medication throughout the experiment.

Data Analysis

Baseline characteristics and exercise responses were summarized and tabulated. The covariate of the study will be the participants' resting BP before exercise. Comparing and contrasting the covariate will give the study an extra dimension of validity to prove which exercise protocol is the best predictor of reducing BP. Shapiro-Wilk test was tested for the normality of the data distribution. Absolute values and BP change (BP delta [Δ] = BP post-exercise − BP pre-exercise) are reported as mean ± SD values. $H_0$1 and $H_0$2 were used to examine the effect of exercise intensity on BP, and a repeated-measures analysis of covariance (ANCOVA) was used considering initial levels. $H_0$3 was used a Two-Way ANCOVA to examine the effect of sex and intensity on BP responses in adults over 65 years of age. If a significant interaction was observed, post hoc mean comparisons were performed. Paired sample t-tests were performed to compare BP values between exercise intensities at baseline and at each time point after exercise. $P < .05$ was significant. Data were analyzed using IBM SPSS Statistics 28.0.1 (IBM Corporation).

Inferential statistics will be the data analysis used in the study. According to Guetterman (2019), inferential statistics examines differences among groups and the relationships among variables, i.e., older adults, and the association between low and moderate-intensity exercise on blood pressure response. Inferential statistics is an umbrella term that uses t-test, ANCOVA, correlation, and regression. Data will be analyzed using the IBM SPSS Statistics Software. Descriptive will be analyzed using measures of central tendency. Descriptive statistics are specific methods used to calculate, describe, and summarize collected research data logically, meaningfully, and efficiently. The central tendency is the three measures of the center (mean, median, or mode) (Vetter, 2017). ANCOVA will be used to examine the difference in the effects of intensity. Two-ANCOVA will be used to explore the difference in change in each BP in males and females of low and moderate intensity immediately after and over the 30-minute post-exercise period.

The BP responses before and after the exercise protocol will be compared with the paired t-test. According to Wadhwa & Marappa-Ganeshan (2023), a t-test is a ratio that quantifies how significant the difference is between the 'means' of two groups while considering their variance or distribution. Furthermore, utilizing logistic regression, all the categorical variables (age, sex, use of blood pressure medications) were combined to see how they all worked together to predict a change in BP. The objective was to see whether the SBP reduction was statistically significant or if the categorical variables were associated with a change in SBP. Lastly, a Pearson correlation test was completed to determine a correlation between age and SBP difference and DBP difference, respectively, and to determine if there was a correlation between SBP difference and DBP difference. The second measurable outcome was the difference in DBP following intervention (pre-intervention DBP –post-intervention DBP). The DBP obtained before and after the exercise protocol were compared utilizing the paired t-test to see if a significant difference occurred. Furthermore, all the categorical variables were combined using logistic regression to see how they all worked together to predict a change in DBP. The objective was to see whether the DBP reduction was statistically significant or if the categorical variables could predict a change in DBP.

Variables within the research study are commonplace in the realm of experimentation. To further detail the research study, variables that will be examined are the current exercise level of the participants and any BP medications that may affect the participants' pressure. On the survey, the participants will be asked three things related to medication: are they currently taking medication, are they on any BP medications, and are they on BP meds that may effect the pressure during exercise.

Analysis of Covariance (ANCOVA) is one of medical research's most frequently used statistical models and is most useful when comparing differences in variance (Kim, 2017). In correlated data, the change in the magnitude of one variable is associated with a change in the magnitude of another variable, either in the exact (positive correlation) or in the opposite (negative correlation) direction (Schober et al., 2018). Grant et al. (2019) report that multivariable regression models determine the association between a dependent variable (i.e., an outcome of interest) and more than one independent variable. ANCOVA will be used to examine the difference in the effects of intensity. Two-Way ANCOVA will be used to explore the difference in change in each BP in males and females of low and moderate intensity immediately after and over the 30-minute post-exercise period.

CHAPTER FOUR: RESULTS

Overview

Data from the study was analyzed using SPSS statistical software. First, data was checked for missing data and outliers. H1 was tested using an analysis of covariance (ANCOVA). Both diastolic and systolic blood pressure metrics were independently analyzed. Resting diastolic and resting systolic blood pressures were covariates; the group assignment was the independent variable, and immediate post-exercise diastolic and systolic blood pressures were dependent variables. H2 was tested using ANCOVA, and diastolic and systolic blood pressure metrics were analyzed independently. H3 was tested using Two-Way ANCOVA. Resting diastolic and resting systolic blood pressures were covariates; the male and female group assignment was the independent variable, and immediate post-exercise and 30 minutes post-exercise diastolic and systolic blood pressures were dependent variables.

Research Question(s)

RQ1: *What is the relationship between exercise intensity (low and moderate) and blood pressure response immediately following a single bout of exercise in adults aged 65 and older?*

RQ2: *How does exercise intensity affect systolic and diastolic BP response following an acute bout of exercise among adults aged 65 and older?*

RQ3: *What is the statistical significance of post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise?*

Hypothesis(es)

$H_0$1: *No statistically significant difference exists between the BP response of older adults 65 and older after a single bout of exercise at low intensity compared to those who exercise at moderate intensity.*

$H_0$2: *In older adults aged 65 and older, systolic and diastolic BP will decrease proportionality after a single bout of low to moderate intensity.*

$H_0$3: *There is no statistically significant difference in post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise to low or moderate intensity.*

Descriptive Characteristics

A total of 120 participants from one community-based hospital completed the study, including 60 in the low-intensity group and 60 in the moderate-intensity group. Of these, 60 (50%) were males and 60 (50%) were females, and the mean (SD) age was 74.8 (6.3) years. The ethnic groups of participants represented in the study were Caucasian (59.2%), African American (38.3%), Hispanic (.8%), and Asian (.8%). The average systolic and diastolic BP prior to exercise was 134.48 (17.463) and 75.50 (11.526), respectively. The average systolic and diastolic BP immediately after exercise was 144.10 (18.058) and 75.03 (9.017), respectively. The average systolic and diastolic BP 30 minutes after exercise was 127.57 (16.367) and 73.15 (9.858), respectively. From a demographic standpoint, the patient population was somewhat diverse with Caucasians being the predominant race. Out of the 120 participants in the study, six reported to be current everyday smokers. Five of which have reported to smoke > 3 years and one participant reported to smoke < 6 months.

Descriptive Statistics

	Mean	Std. Deviation	N
Participant	60.50	34.785	120
Age	74.80	6.347	120
SBPbefore	134.48	17.463	120
DBPbefore	75.50	11.526	120
SBPafter	144.10	18.058	120
DBPafter	75.03	9.017	120
SBP30minafter	127.57	16.367	120
DBP30minafter	73.15	9.858	120

Statistics

		Participant	Sex	Age	SBPbefore	DBPbefore	SBPafter	DBPafter	SBP30minafter	DBP30minafter
N	Valid	120	120	120	120	120	120	120	120	120
	Missing	0	0	0	0	0	0	0	0	0
Mean		60.50		74.80	134.48	75.50	144.10	75.03	127.57	73.15
Median		60.50		74.00	134.00	76.00	142.00	74.00	125.50	72.00
Mode		1[a]		78	140	70	150	70[a]	118	70
Std. Deviation		34.785		6.347	17.463	11.526	18.058	9.017	16.367	9.858
Skewness		.000		.346	.835	.006	.397	.262	.810	.060
Std. Error of Skewness		.221		.221	.221	.221	.221	.221	.221	.221
Kurtosis		-1.200		-.337	1.294	-.760	.352	.252	.988	-.440
Std. Error of Kurtosis		.438		.438	.438	.438	.438	.438	.438	.438
Range		119		28	89	51	98	48	84	46
Minimum		1		65	104	50	104	54	96	50
Maximum		120		93	193	101	202	102	180	96

a. Multiple modes exist. The smallest value is shown

	Resting	Immediately after	30 minutes after
Low Intensity SBP	135.65	142.15	127.95
Moderate Intensity SBP	134.5	146.05	127.18
Low Intensity DBP	76.7	74.73	73.4
Moderate Intensity DBP	75.5	75.33	72.9

Results

Specific Aim 1 – Blood Pressure Response

Our first research question was to examine relationship between exercise intensity (low and moderate) and blood pressure response immediately following a single bout of exercise in adults aged 65 and older.

Systolic Blood Pressure

H1 confirms no statistically significant difference between the SBP response of older adults 65 and older after a single bout of exercise at low intensity compared to those who exercise at moderate intensity [F (1,117) = 3.640, *p* .059]. Therefore, we failed to reject the null hypothesis. The partial Eta Squared value indicates the effect size and should be compared with Cohen's guidelines (0.2 – small effect, 0.5 – moderate effect, 0.8 – large effect). Partial eta squared accounted for 3% of the variance, indicating a small effect size. No post hoc analysis is needed as the ANCOVA is not significant. Per the Shapiro-Wilks Test of Normality, SBP immediately after low-intensity exercise was statistically significant at p =.009, which indicates data is not normally distributed. SBP immediately after moderate-intensity exercise was not statistically significant at p =.251, indicating data is normally distributed. Per the Shapiro-Wilks Test of Normality, SBP 30 minutes after low-intensity exercise was statistically significant at p =.006, which indicates data is not normally distributed. SBP 30 minutes after moderate-intensity exercise was not statistically significant at p =.687, indicating data is normally distributed. There is significant linearity a p <.001 between SBP before and SBP immediately after exercise (Linearity ANOVA Table). There is a non-significant deviation from linearity at p = 0.42; hence, SBP before and SBP immediately after have a linear relationship.

Diastolic Blood Pressure

H1 confirms no statistically significant difference between the DBP response of older adults 65 and older after a single bout of exercise at low intensity compared to those who exercise at moderate intensity [F (1,117) = 1.367, *p* =.245]. Therefore, we failed to reject the null hypothesis. Per the Shapiro-Wilks Test of Normality, DBP immediately after low-intensity exercise was not statistically significant at *p* =.281, which indicates data is normally distributed. DBP immediately after moderate-intensity exercise was not statistically significant at *p* =.543, indicating data is normally distributed. Per the Shapiro-Wilks Test of Normality, DBP 30 minutes after low-intensity exercise was not statistically significant at *p* =.056, which indicates data is normally distributed. DBP 30 minutes after moderate-intensity exercise was not statistically significant at *p* =.577, indicating data is normally distributed. The assumption for normality has been met.

There was significant linearity a *p* <.001 between DBP before and DBP immediately after exercise (Linearity ANOVA Table). There was no significant deviation from linearity at *p* =.300; hence, DBP before and DBP immediately after have a linear relationship. Partial eta squared accounted for 1.2% of the variance, indicating a small effect size. Levene's Test of Equality of Error Variance was insignificant at *p* =.929, indicating that the group variance is equal (hence, the assumption of homogeneity of variance is not violated).

There was no statistically significant difference in SBP immediately after exercise [F (1,117) = 3.640, *p* =.059] between exercise intensity while adjusting for SBP before exercise. Descriptive factors accounted for 3% of the variance. (see Table 1)

Table 1

SBP Immediately After Exercise

Tests of Between-Subjects Effects

Dependent Variable: SBPafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12421.333[a]	2	6210.666	27.542	<.001	.320
Intercept	8741.560	1	8741.560	38.765	<.001	.249
SBPbefore	11965.033	1	11965.033	53.060	<.001	.312
Intense	820.917	1	820.917	3.640	.059	.030
Error	26383.467	117	225.500			
Total	2530582.000	120				
Corrected Total	38804.800	119				

a. R Squared = .320 (Adjusted R Squared = .308)

There was no statistically significant difference in DBP after exercise [F (1,117) = 1.367, *p* =.245] between exercise intensity while adjusting for DBP before exercise. Descriptive factors accounted for 1.2% of the variance. (see Table 2)

Table 2

DBP Immediately After Exercise

Tests of Between-Subjects Effects

Dependent Variable: DBPafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2905.245[a]	2	1452.622	25.102	<.001	.300
Intercept	4854.754	1	4854.754	83.893	<.001	.418
DBPbefore	2894.445	1	2894.445	50.018	<.001	.299
Intense	79.090	1	79.090	1.367	.245	.012
Error	6770.622	117	57.869			
Total	685276.000	120				

Corrected Total	9675.867	119				

a. R Squared = .300 (Adjusted R Squared = .288)

There was no statistically significant difference in SBP 30 minutes after exercise [F (1,117) = .109, *p* =.742] between exercise intensity while adjusting for SBP before exercise. Descriptive factors accounted for .1% of the variance. (see Table 3)

Table 3

Systolic BP 30 Minutes After Exercise

Tests of Between-Subjects Effects

Dependent Variable: SBP30minafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14843.355[a]	2	7421.678	50.976	<.001	.466
Intercept	3369.510	1	3369.510	23.144	<.001	.165
SBPbefore	14825.722	1	14825.722	101.832	<.001	.465
Intense	15.834	1	15.834	.109	.742	.001
Error	17034.112	117	145.591			
Total	1984668.000	120				
Corrected Total	31877.467	119				

a. R Squared = .466 (Adjusted R Squared = .457)

There was no statistically significant difference in DBP 30 minutes after exercise [F (1,117) = .210, p = .648] between exercise intensity while adjusting for DBP before exercise. Descriptive factors accounted for .2% of the variance. (see Table 4)

Table 4

Diastolic BP 30 Minutes After Exercise

Tests of Between-Subjects Effects

Dependent Variable: DBP30minafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3815.360[a]	2	1907.680	28.800	<.001	.330
Intercept	3454.269	1	3454.269	52.149	<.001	.308
DBPbefore	3807.860	1	3807.860	57.487	<.001	.329
Intense	13.899	1	13.899	.210	.648	.002
Error	7749.940	117	66.239			
Total	653676.000	120				
Corrected Total	11565.300	119				

a. R Squared = .330 (Adjusted R Squared = .318)

Specific Aim 2 – Proportionality and BP response

Our second research question was to examine which exercise intensity affect systolic and diastolic BP response following an acute bout of exercise among adults aged 65 and older.

Systolic Blood Pressure

H2 confirms there was no statistically significant difference that systolic BP will decrease proportionality after a single bout of low to moderate intensity exercise F (1,117) = 3.640, *p* =.059]. Therefore, we failed to reject the null hypothesis. No statistically significant difference in SBP immediately after exercise was seen between exercise intensity while adjusting for SBP before exercise (see Table 1). There was no statistically significant difference in SBP 30 minutes after exercise [F (1,117) = .109, *p* =.742] between exercise intensity while adjusting for SBP before exercise. The central purpose of this study was to examine systolic and diastolic blood pressure responses in low—to moderate-intensity exercise using a recumbent bike. This was tested through a series of univariate analyses, leading to the following results: The partial Eta Squared value indicates the effect size and should be compared with Cohen's guidelines (0.2 – small effect, 0.5 – moderate effect, 0.8 – large effect). Partial eta squared accounted for 3% of the variance, indicating a small effect size. This value describes how much variance in the dependent variable is explained by the independent variable.

Per the Shapiro-Wilks Test of Normality, SBP 30 minutes after low-intensity exercise was statistically significant at p =.006, which indicates data is not normally distributed. SBP 30 minutes after moderate-intensity exercise was not statistically significant at p =.687, indicating data is normally distributed. There is significant linearity a p <.001 between SBP before and SBP 30 minutes after exercise. There is no significant deviation from linearity at p = 0.179; hence, SBP before and SBP 30 minutes after have a linear relationship. Levene's Test of Equality of Error Variance was insignificant at p =.900, indicating that the group variance is equal (hence, the assumption of homogeneity of variance is not violated).

<u>Diastolic Blood Pressure</u>

H2 confirms no statistically significant difference that diastolic BP will decrease proportionality after a single bout of low to moderate intensity exercise (1,117) = 1.367, p =.245]. Therefore, we failed to reject the null hypothesis since there was no statistically significant difference in DBP after exercise between exercise intensity while adjusting for DBP before exercise. There was no statistically significant difference in DBP 30 minutes after exercise [F (1,117) = .210, p = .648] between exercise intensity while adjusting for DBP before exercise. Per the Shapiro-Wilks Test of Normality, DBP 30 minutes after low-intensity exercise was not statistically significant at p =.056, which indicates data is normally distributed. DBP 30 minutes after moderate-intensity exercise was not statistically significant at p =.577, indicating data is normally distributed. There is significant linearity a p <.001 between DBP before and DBP 30 minutes after exercise. There is no significant deviation from linearity at p =.879; hence, DBP before and DBP 30 minutes after have a linear relationship.

Specific Aim 3 – Sex and BP Response

Our third research question was to examine statistical significance of post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise.

Systolic Blood Pressure

H3 confirms no statistically significant difference exists in post-exercise systolic blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise at low or moderate intensity [F (1,111) = 2.141, *p* .146]. Therefore, we failed to reject the null hypothesis. There was no statistically significant difference in SBP after exercise at either intensity [F (1,111) = 2.141, *p* =.146] between sexes while adjusting for SBP before exercise. Descriptive factors accounted for 30.6% of the variance. Per the Shapiro-Wilks Test of Normality, SBP 30 minutes after low-intensity exercise was not statistically significant in males at *p* =.079 compared to females at *p* =.001 which indicates data is not normally distributed. SBP 30 minutes after low-intensity exercise was statistically significant at *p* =.006 indicating data is not normally distributed. SBP 30 minutes after moderate-intensity exercise was not statistically significant at *p* =.687 indicating data is normally distributed. There is no significant deviation from linearity at *p* = .179; hence, SBP before and SBP 30 minutes after do not have a linear relationship.

Diastolic Blood Pressure

H3 confirms no statistically significant difference exists in post-exercise diastolic blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise at low or moderate intensity [F (1,111) = .111, *p* .740]. Per the Shapiro-Wilks DBP immediately after low-intensity exercise was not statistically significant at *p* =.281, indicating data is normally distributed. DBP immediately after moderate-intensity exercise was not statistically significant at *p* =.543, indicating data is normally distributed. There is significant linearity a *p* =.001 between DBP before and DBP immediate after exercise. There is no significant deviation from linearity at *p* = .300; hence, DBP before and DBP immediately after do not have a linear relationship. There was no statistically significant difference in DBP after exercise at either intensity [F (1,111) = .111, *p* =.740] between sexes while adjusting for DBP before exercise. Descriptive factors accounted for .63% of the variance.

Table 5

Sex and SBP immediately after

Tests of Normality[c]

	Sex	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
SBPafter	1	.100	59	.200*	.978	59	.364
	2	.057	60	.200*	.986	60	.732

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction
c. SBPafter is constant when Sex = 1. It has been omitted.

SBP immediately after low-intensity exercise was statistically significant at *p* =.009 (see Table 6), indicating data is not normally distributed. SBP immediately after moderate-intensity exercise was not statistically significant at *p* =.251 (see Table 6), indicating data is normally distributed.

Table 6

Intensity and Sex SBP immediately after

Tests of Normality

Intense	Kolmogorov-Smirnov[a]	Shapiro-Wilk

		Statistic	df	Sig.	Statistic	df	Sig.
SBPafter	1	.111	60	.062	.944	60	.009
	2	.079	60	.200*	.975	60	.251

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 7

Linearity Table

There is significant linearity a p =.001 between SBP before and SBP immediate after exercise (see Table 7). There is significant deviation from linearity at p = .042; hence, SBP before and SBP immediately after have a linear relationship.

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
SBPafter * SBPbefore	Between Groups	(Combined)	24027.046	42	572.073	2.981	<.001
		Linearity	11600.416	1	11600.416	60.444	<.001
		Deviation from Linearity	12426.631	41	303.089	1.579	.042
	Within Groups		14777.754	77	191.919		
	Total		38804.800	119			

There was no statistically significant difference in SBP after exercise at either intensity [F (1,111) = 2.141, *p* =.146] between sexes while adjusting for SBP before exercise. Descriptive factors accounted for 30.6% of the variance. (see Table 8)

Table 8

Tests of Between-Subject Effects (ANCOVA)

Tests of Between-Subjects Effects

Dependent Variable: SBPafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	13235.978[a]	8	1654.497	7.183	<.001	.341	57.460	1.000
Intercept	9209.750	1	9209.750	39.982	<.001	.265	39.982	1.000
Intense * Sex	916.131	3	305.377	1.326	.270	.035	3.977	.345
Intense * SBPbefore	303.724	1	303.724	1.319	.253	.012	1.319	.207
Sex * SBPbefore	25.440	1	25.440	.110	.740	.001	.110	.063
Intense * Sex * SBPbefore	493.282	1	493.282	2.141	.146	.019	2.141	.306
Error	25568.822	111	230.350					
Total	2530582.000	120						
Corrected Total	38804.800	119						

a. R Squared = .341 (Adjusted R Squared = .294)
b. Computed using alpha = .05

Per the Shapiro-Wilks Test of Normality, SBP 30 minutes after low-intensity exercise was not statistically significant in males at *p* =.079 compared to females at *p* =.001 (see Table 9), which indicates data is not normally distributed.

SBP 30 Minutes After Exercise

Table 9

Sex and SBP 30 minutes after

Tests of Normality[b]

	Sex	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
SBP30minafter	1	.111	59	.066	.964	59	.079
	2	.102	60	.189	.926	60	.001

a. Lilliefors Significance Correction
b. SBP30minafter is constant when Sex = 1. It has been omitted.

SBP 30 minutes after low-intensity exercise was statistically significant at p =.006 (see Table 10), indicating data is not normally distributed. SBP 30 minutes after moderate-intensity exercise was not statistically significant at p =.687 (see Table 10), indicating data is normally distributed.

Table 10

Intensity and SBP 30 minutes after

Tests of Normality

	Intense	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
SBP30minafter	1	.132	60	.011	.940	60	.006
	2	.065	60	.200*	.985	60	.687

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

There is significant linearity a p =.001 between SBP before and SBP immediate after exercise.

There is no significant deviation from linearity at $p = .179$; hence, SBP before and SBP 30 minutes after do not have a linear relationship (see Table 11).

Table 11

Linearity Table

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
SBP30minafter * SBPbefore	Between Groups	(Combined)	21717.613	42	517.086	3.919	<.001
		Linearity	14827.521	1	14827.521	112.376	<.001
		Deviation from Linearity	6890.092	41	168.051	1.274	.179
	Within Groups		10159.854	77	131.946		
	Total		31877.467	119			

There was no statistically significant difference in SBP 30 minutes after exercise at either intensity [$F(1,111) = 2.503$, $p = .116$] between sexes while adjusting for SBP before exercise. Descriptive factors accounted for 34.8% of the variance. (see Table 12)

Table 12

Tests of Between-Subject Effects (ANCOVA)

Tests of Between-Subjects Effects

Dependent Variable: SBP30minafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	16543.645[a]	8	2067.956	14.970	<.001	.519	119.758	1.000
Intercept	4057.466	1	4057.466	29.372	<.001	.209	29.372	1.000
Intense * Sex	1414.910	3	471.637	3.414	.020	.084	10.242	.756

Intense * SBPbefore	947.045	1	947.045	6.856	.010	.058	6.856	.737
Sex * SBPbefore	393.659	1	393.659	2.850	.094	.025	2.850	.387
Intense * Sex * SBPbefore	345.824	1	345.824	2.503	.116	.022	2.503	.348
Error	15333.821	111	138.143					
Total	1984668.000	120						
Corrected Total	31877.467	119						

a. R Squared = .519 (Adjusted R Squared = .484)
b. Computed using alpha = .05

Table 13

Sex and DBP immediately after

Tests of Normality[c]

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Sex	Statistic	df	Sig.	Statistic	df	Sig.
DBPafter	1	.103	59	.186	.980	59	.461
	2	.082	60	.200*	.983	60	.569

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction
c. DBPafter is constant when Sex = 1. It has been omitted.

DBP immediately after low-intensity exercise was not statistically significant at *p* =.281 (see Table 14), indicating data is normally distributed. DBP immediately after moderate-intensity exercise was not statistically significant at *p* =.543 (see Table 14), indicating data is normally distributed.

Table 14

Intensity and DBP immediately after

Tests of Normality

	Intense	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
DBPafter	1	.105	60	.095	.976	60	.281
	2	.087	60	.200*	.983	60	.543

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

There is significant linearity a *p* =.001 between DBP before and DBP immediate after exercise (see Table 15). There is no significant deviation from linearity at *p* = .300; hence, DBP before and DBP immediately after do not have a linear relationship.

Table 15

Linearity Table

			Sum of Squares	df	Mean Square	F	Sig.
DBPafter * DBPbefore	Between Groups	(Combined)	5181.052	38	136.343	2.457	<.001
		Linearity	2826.155	1	2826.155	50.929	<.001
		Deviation from Linearity	2354.897	37	63.646	1.147	.300
	Within Groups		4494.814	81	55.492		
	Total		9675.867	119			

There was no statistically significant difference in DBP after exercise at either intensity [F (1,111) = .111, *p* =.740] between sexes while adjusting for DBP before exercise. Descriptive factors accounted for .63% of the variance. (see Table 16)

Table 16

Tests of Between-Subject Effects (ANCOVA)

Tests of Between-Subjects Effects

Dependent Variable: DBPafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	3022.471[a]	8	377.809	6.303	<.001	.312	50.425	1.000
Intercept	4803.526	1	4803.526	80.138	<.001	.419	80.138	1.000
Intense * Sex	80.489	3	26.830	.448	.719	.012	1.343	.137
Intense * DBPbefore	4.385	1	4.385	.073	.787	.001	.073	.058
Sex * DBPbefore	55.846	1	55.846	.932	.337	.008	.932	.160
Intense * Sex * DBPbefore	6.626	1	6.626	.111	.740	.001	.111	.063
Error	6653.395	111	59.940					
Total	685276.000	120						
Corrected Total	9675.867	119						

a. R Squared = .312 (Adjusted R Squared = .263)
b. Computed using alpha = .05

DBP 30 Minutes After

Per the Shapiro-Wilks Test of Normality, DBP 30 minutes after low-intensity exercise was not statistically significant in males at *p* =.401 compared to females at *p* =.248 (see Table 17), which indicates data is normally distributed.

Table 17

Sex and DBP 30 minutes after

Tests of Normality[c]

	Sex	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
DBP30minafter	1	.090	59	.200*	.979	59	.401
	2	.103	60	.186	.975	60	.248

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction
c. DBP30minafter is constant when Sex = 1. It has been omitted.

DBP 30 minutes after low-intensity exercise was statistically significant at *p* =.056 (see Table 18), indicating data is not normally distributed. DBP 30 minutes after moderate-intensity exercise was not statistically significant at *p* =.577 (see Table 18), indicating data is normally distributed.

Table 18

Intensity and DBP 30 minutes after

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Intense	Statistic	df	Sig.	Statistic	df	Sig.
DBP30minafter	1	.076	60	.200*	.962	60	.056
	2	.113	60	.056	.983	60	.577

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

There is significant linearity a *p* =.001 between DBP before and DBP 30 minutes after exercise (see Table 19). There is no significant deviation from linearity at *p* = .879; hence, DBP before and DBP 30 minutes after do not have a linear relationship.

Table 19

Linearity Table

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
DBP30minafter * DBPbefore	Between Groups	(Combined)	5695.071	38	149.870	2.068	.003
		Linearity	3801.462	1	3801.462	52.454	<.001
		Deviation from Linearity	1893.609	37	51.179	.706	.879
	Within Groups		5870.229	81	72.472		
	Total		11565.300	119			

There was no statistically significant difference in DBP 30 minutes after exercise at either intensity [F (1,111) = .315, *p* =.576] between sexes while adjusting for DBP before exercise. Descriptive factors accounted for .86% of the variance. (see Table 20)

Table 20

Tests of Between-Subject Effects (ANCOVA)

Tests of Between-Subjects Effects

Dependent Variable: DBP30minafter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	4206.041[a]	8	525.755	7.930	<.001	.364	63.440	1.000
Intercept	3540.767	1	3540.767	53.406	<.001	.325	53.406	1.000
Intense * Sex	83.746	3	27.915	.421	.738	.011	1.263	.132

Intense * DBPbefore	59.876	1	59.876	.903	.344	.008	.903	.156
Sex * DBPbefore	1.615	1	1.615	.024	.876	.000	.024	.053
Intense * Sex * DBPbefore	20.860	1	20.860	.315	.576	.003	.315	.086
Error	7359.259	111	66.300					
Total	653676.000	120						
Corrected Total	11565.300	119						

a. R Squared = .364 (Adjusted R Squared = .318)

b. Computed using alpha = .05

CHAPTER FIVE: CONCLUSIONS

Overview

Our study investigates the impact of low- and moderate-intensity exercise on the blood pressure response of hypertensive older adults. The goal of this research was to ascertain whether exercise intensity can significantly reduce diastolic and systolic blood pressure in older adults by emphasizing sustainable and accessible forms of physical activity. This dissertation endeavors to offer evidence-based recommendations for the integration of low-intensity and moderate-intensity exercise into treatment plans for hypertension and older populations. In addition to improving cardiovascular health, this will also improve the overall quality of life. An exhaustive examination of this clinical trial will be conducted.

Discussion

This study examined which exercise intensity (low or moderate intensity) promotes the best hypertension response in older adults. Recognizing the critical need for effective, accessible interventions to manage hypertension in this population, the study aimed to evaluate whether varying exercise intensities could offer distinct benefits. By comparing the outcomes of low- and moderate-intensity exercises, this research sought to determine the most beneficial approach to reduce blood pressure and determine if we can improve cardiovascular health among hypertensive older adults. Muntner et al. (2022) performed a cross-sectional design from the US National Health & Nutritional Survey (NHANES), and found that among US people aged 65 and older, normal blood pressure was less common than increased blood pressure/hypertension, even after multivariable adjustment. The findings from Muntner et al. (2022) are intended to inform clinical guidelines and support the development of tailored exercise programs that maximize health benefits while ensuring safety and feasibility for older adults with hypertension. Studies in older adults are limited due to the lack of participation of social connection (Suragarn et al., 2021). Contrary to Muntners et al.'s study, identifying US people ≥65 with normal BP may help prevent the current rise in mean SBP with age in the US. The aim of Muntners et al study were to ascertain the proportion of US individuals, categorized by age, who have normal blood pressure, and to discover lifestyle factors and health disorders that are linked to having normal blood pressure among US adults aged 65 years and older. In comparison to our study, Muntner et al assessed BP measurement following a standardized protocol with rigorous quality control procedures.

RQ1: What is the relationship between exercise intensity (low and moderate) and blood pressure response immediately following a single bout of exercise in adults aged 65 and older?

The main conclusion of our study was that there was no statistically significant disparity in blood pressure response between the low and moderate exercising senior adults immediately after exercising. A more prominent decrease in post exercise blood pressure may be seen at higher aerobic intensities but there is a direct correlation in a decrease in post exercise blood pressure response at either intensities in the present study (Lopes et al., 2020). Lopes et al., 2020, conducted a RCT that indicated both aerobic exercise intensities (30%–60% HRR) induced an immediate decrease in systolic BP in physically active adults. There was reduction in SBP following any level of intensity in our study. However, a decrease in SBP was observed throughout the 30-minute interval after the exercise session was finished. In comparison with Lopes at al. study, the absence of a substantial decrease in diastolic blood pressure is not unexpected, as the baseline values were nearly normal, which reduces the likelihood of achieving a lower blood pressure following an exercise session. Low-intensity exercise—which can be more easily tolerated by older adults with hypertension—induced an immediate benefit in the older population (Lopes et al., 2020). According to Lopes et al., (2020) a prior study conducted on elderly individuals with hypertension who engaged in regular exercise demonstrated that two 10-minute sessions of walking at an intensity of 40% to 60% of the heart rate reserve (HRres) resulted in an immediate drop in systolic blood pressure, although diastolic blood pressure remained unchanged. A study by Mytinger et al, (2020) prescribed exercise by using metabolic equivalents (MET) to determine VO_2max (1 MET = 3.5 mL/kg/min), and workloads in cardiac rehabilitation are easily evaluated by calculating exercise METs. In our study, we utilized %HRR which indicates what intensity levels the subjects exercise in based on their HR. For instance, exercise intensity can be determined as a percentage of the peak values (e.g., %heart rate reserve or %VO2max) when precise peak heart rate and exertion data are available.

Kazeminia et al. (2020) conducted a systematic review and meta-analysis that found mild and moderate-intensity programs influence blood pressure reduction. Our study found that BP slightly decreases after 30-minutes of exercise completion but that data suggests the decreased is not significant. Even low-intensity exercise—which can be more easily tolerated by older adults with hypertension—induced an immediate benefit in active adults (Kazeminia et al., 2020). The influence of aerobic exercises on hypertension has been primarily examined in long-term exercise programs (at least three months) that involve a high intensity and a high number of sessions per week (5 days per week). However, our study involved a single exercise bout at either low or moderate intensity. The study conducted by Kazeminiaet al., which aimed to compare the cardiovascular indicators of older adults to the effects of aerobic short-term and long-term exercise programs with mild and moderate intensities, revealed that the short-term program did not have any effect on reducing systolic blood pressure, but it did decrease diastolic blood pressure (Kazeminia et al., 2020). Kazeminia et al. (2020) found that the systolic changes before the intervention were 137.1 ± 8.09 and 132.98 ± 0.96 after the intervention. The diastolic changes were 80.3 ± 0.85 before the intervention and 76.0 ± 6.56 after the intervention. These differences were statistically significant ($P < 0.01$). Given that our patients' baseline values were slightly elevated, it is anticipated that a lower blood pressure will be obtained following an activity session, therefore the lack of a visible decline in diastolic blood pressure is not surprising (Vischer, & Burkard, 2021). Our study indicated a ±3 mm Hg difference in DBP at rest compared to immediately after and 30-minutes after exercise. According to Lopes et al., (2020) their team observed a systolic BP decrease after the session between 8.7 and 10 mm Hg in the 30% session and between 10.5 and 11.4 mm Hg in the 60% session. According to Lopes et al., (2020) the reduction in BP observed after a single exercise session demonstrated a strong positive connection with the prolonged decrease in BP observed after eight weeks of exercise training, signifying that the acute reduction in BP may be linked to long-term adaptations to exercise (Lopes et al., 2020).

In both exercise intensities a linear relationship was seen in SBP and DBP immediately following the exercise bout. According to Lopes et al., (2020), athletes aged 12-35 who consistently perform aerobic exercise (soccer, swimming, and track) typically see a smaller decrease in blood pressure after exercise compared to inactive individuals. Hence, the inclusion of exclusively physically active persons in the study, led to a decrease in BP levels, thereby emphasizing the importance of exercise in regulating blood pressure Lopes et al., (2020). The study conducted by Kazeminia et al. (2020) examined the effects of exercise regimens on individuals aged >60 years old with hypertension, specifically focusing on the influence of long-term moderate-intensity exercise. Kazeminia et al. (2020) found that the systolic changes before and after the intervention were 137.8 and 132.08, respectively. Similarly, the diastolic changes were 80.3 and 76.6, which indicate that exercise leads to a considerable reduction in age-related hypertension. In contrast, the findings of our study indicated a decrease in blood pressure in the samples but did not reach statistical significance. According to Assah et al. (2021), a study of men age 30-79 with pre- to stage 1 hypertension experienced significant BP reductions (2.8 ± 1.6, 5.4 ± 1.4, and 11.7 ± 1.5 mm Hg, respectively) after just one session of low, moderate, and vigorous-intensity exercise compared to a non-exercise control session over 9 hours. In our study, SBP decreased by ± 8mm Hg and DBP by ± 3mm Hg, respectively. Even though SBP and DBP decreased after exercise, the findings were not found to be significant. Similar findings in our study were compared with a study by Assah et al., (2021) which investigated the reduction in blood pressure following physical activity was more significant and more enduring after higher-intensity aerobic exercise. The short-term exercise program did not lower systolic blood pressure (SBP), but it did lower diastolic blood pressure (DBP), according to research on the effects of different aerobic exercise program durations and intensities on cardiovascular markers in older adults (Kazeminia et al., 2020). Kazeminia et al., (2020) reports aerobic exercise programs offer many benefits in comparison to different durations and intensities on cardiovascular indicators in older adults (mean age: 67±6 years; range: 53 to 86 years). The age range of the participants in the study by Kazeminia compares to our participants (> 65 years old). The results showed that the short-term program did not reduce systolic blood pressure but decreased diastolic blood pressure (Kazeminia et al., 2020). According to Alpsoy (2020), aerobic exercise lowers systolic BP by 3.84 mmHg and diastolic BP by 2.58 mmHg, according to a meta-analysis of 54 randomized studies of 2400 older adults. The whole study population—hypertensive, normotensive, underweight, overweight, white, black, and Asian—experienced this impact regardless of aerobic exercise frequency, intensity, or kind (Alpsoy, 2020). According to our study, the average systolic and diastolic BP prior to exercise was 134.48 (17.463) and 75.50 (11.526), respectively. The average systolic and diastolic BP immediately after exercise was 144.10 (18.058) and 75.03 (9.017), respectively. The average systolic and diastolic BP 30 minutes after exercise was 127.57 (16.367) and 73.15 (9.858), respectively. The ethnic groups of participants represented in the study were Caucasian (59.2%), African American (38.3%), Hispanic (.8%), and Asian (.8%).

RQ2: How does exercise intensity affect systolic and diastolic BP response following an acute bout of exercise among adults aged 65 and older?

The systolic blood pressure (SBP) increased to 144.1 (with a standard deviation of 18.058) and the diastolic blood pressure (DBP) increased to 75.03 (with a standard deviation of 9.017) immediately following a single session of exercise in both sexes at low and moderate intensity; however, our study results showed that there was no statistically significant impact of exercise intensity on the response. Our study's findings indicated that post-exercise SBP decreased from 144.1 to 127.57 (an 8.85% decrease) and DBP decreased from 75.03 to 73.15 (a 9.74%) in the immediate post-exercise period. As post-exercise BP reduction is influenced by baseline values, the present study showed a linear relationship in pre-exercise (SBP & DBP) compared to post-exercise BP. This may have been to a vasodilatory response from the exercise bout (Iellamo et al., 2021). According to de Brito et al. (2019), due to vascular dilatation, post-exercise hypotension lowers BP for several hours after a single workout. The variability of experimental designs ranges from evaluating PEH during the first 5 min to first 3 hrs post-exercise. Our study took BP readings immediately after exercise and 30-minutes after the completion of the exercise bout. De Brito et al., (2019) reports the advantage of demanding only one experimental session, with as few as two blood pressure measurements (pre- vs. post-exercise); however, we would strongly suggest the inclusion of more measurements over time rather than the bare minimum of two. In comparison, our study utilized only one exercise session with three total blood pressure readings per participant.

Carpio-Rivera et al., (2016) performed a meta-analytic investigation of sixty-five studies which enrolled 1408 participants (931 males, 455 females, 22 with undisclosed gender), with a mean age of 36.1 ± 15.1 years old. The individuals who exhibited the most significant blood pressure reduction were the same ones with the highest blood pressure values before exercising. This aligns with the existing evidence indicating that individuals with higher blood pressure levels prior to exercise experience a more significant decrease in blood pressure after exercising (Carpio-Rivera et al., 2016). According to Nystoriak and Bhatnagar (2018), moderate levels of exercise have been discovered to be reliably connected with a reduction of the risk of cardiovascular disease, especially in individuals over the age of 65 who present with high-normal/grade 1 HTN. All 120 patients in our study had high-normal/grade 1 hypertension, and none of them had blood pressure levels below the low-normal to hypotensive range; therefore, an increase in BP immediately after exercise would be expected.

Our study results portrayed a non-significant response to systolic and diastolic BP after a single bout of exercise. Hence, the systolic and diastolic blood pressure reduction following aerobic exercise was less than expected (−2.75 mmHg and −0.83 mmHg, respectively). The experiment group within our study engaged in one 30-minute session of low- to moderate intensity aerobic exercise. Our trial demonstrated that low-to-moderate intensity aerobic exercise training can lower resting blood pressure in older persons with hypertension in this aged care setting as also exhibited by Alzahrani et al.'s study. Alzahrani et al. (2023) discovered that regular exercise lowers systolic and diastolic blood pressure by 4.0 mmHg in older hypertensive individuals. Their study of 71 overweight, sedentary, hypertensive, and hypercholesterolemic volunteers found a greater reduction in systolic blood pressure (−10 ± 5 mmHg) and diastolic blood pressure (−5 ± 2 mmHg) after three months of vigorous aerobic exercise (Alzahrani et al., 2023). In the current study, a more prominent decrease in SBP and DBP may have been if participants exercised at a higher intensity and had a BP taken at time points past the 30-minute post-exercise period (1h, 2h, 3h)(Nayor, 2023).

RQ3: What is the statistical significance of the post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise?

The results of our study indicate that post-exercise blood pressure response in males aged 65 and older compared to females aged 65 and older following an acute bout of exercise were not statistically significant. Current literature shows resting and exercise BP measures differed in men and women, with both demonstrating fluctuating values for all BP measures (Nayor, 2023). Although the scientific literature reports conflicting results, differences between sexes in the hemodynamic adjustments during and after dynamic exercise tend to disappear when parameters are normalized when the training status is considered (Bassareo & Crisafulli, 2020). Body mass and body composition are parameters that are taken into account while evaluating training status. In our study there was a reduction in blood pressure within 30 minutes after the exercise session. The hypotensive impact was more significant when exercise was used as a preventive intervention in persons who were already physically active. SBP and DBP showed an instantaneous rise during the exercise session, followed by a significant decline 30 minutes following the activity, compared to the baseline resting blood pressure. According to Wen and Wang (2017), aerobic exercise is able to reduce SBP and DBP by about 7- and 5-mm Hg, respectively. In our study, SBP decreased by ± 8mm Hg and DBP by ± 3mm Hg, respectively. The inclusion criteria for Wen and Wang meta-analysis study was that it must be an English paper about the effect of aerobics effect on primary hypertension reduction; must have a definitely diagnostic criterion for primary hypertension: SBP ≥140 mm Hg and DBP ≥90 mm Hg, or being medicated for hypertension; and can provide or calculate the SBP and DBP for hypertensive patients. A consistent regimen of aerobic exercise resulted in a decrease of approximately 5 mmHg in systolic blood pressure and approximately 3 mmHg in diastolic blood pressure in older adults (Alpsoy, 2020). In both males and females aged 65 and older, the results of our study demonstrated an insignificant change in low and moderate intensity immediately following and 30-minutes after exercise. Therefore, hypertensive older adults can benefit from exercise of any intensity.

Implications

Examining the impact of exercise intensity on lowering blood pressure in older individuals could be a valuable addition to existing exercise recommendations. Evidence from randomly controlled trials suggests that either low or moderate-intensity exercise reduces the blood pressure response in older adults (Lopes et al., 2020). As a result, our research suggests that one component of establishing an environment that may improve health outcomes is proper exercise intensity. These results demonstrate the importance of incorporating low to moderate-intensity exercise and health promotion strategies for older adults. The observed blood pressure reductions among older adults highlight the potential of such exercise regimens such a low and moderate intensity exercise as nonpharmacological interventions for hypertension management. The findings of our study poses significant implications for public health policies aimed at reducing the burden of cardiovascular disease among the aging population.

Our hypothesis 1 results demonstrated that a single session of low-intensity exercise does not significantly change the blood pressure response of older adults compared to moderate-intensity exercise. Since there aren't any changes in blood pressure in our study, doctors and fitness experts can confidently tell older people to exercise at a low or moderate intensity to keep their blood pressure in normal ranges. People over 65 can choose an activity that fits their needs, abilities, and health. This might make them want to work out every day. It seems that low- and moderate-intensity exercise both affect blood pressure right away through the same processes, such as vascular function and autonomic regulation. Since it was found that low-intensity exercise works just as well as moderate exercise at treating high blood pressure, public health rules may be changed to get older people to exercise more. Exercise is Medicine claims that since it has similar cardiovascular benefits as moderate-intensity exercise, doctors may feel more secure in recommending less strenuous exercise to older adults, especially those with other health issues or limited physical capabilities. The American College of Sports Medicine developed Exercise is Medicine in 2007 to educate physicians and other health care practitioners about the benefits of exercise and to address the growing divide between health care and fitness (Thompson et al., 2020).

Our hypothesis 2 results were that those aged 65 and above would experience a proportional decrease in both diastolic and systolic blood pressure after engaging in a single session of low to moderate-intensity exercise. Therefore, our study confirmed that elderly adults participating in low to moderate intensity exercise can improve both systolic and diastolic blood pressure. Healthcare providers can now prescribe exercise intensities to control blood pressure based on certain data. The intensity of exercise can be adjusted to accommodate the preferences and requirements of senior individuals. This has the potential to enhance their commitment to maintaining consistent physical activity regimens. The idea suggests that there is a physiological mechanism that controls the response of diastolic and systolic blood pressure, similar to how the body reacts to low to moderate intensity exercise. Fitness professionals can enhance our understanding of how various exercise intensities impact cardiovascular health. Healthcare providers should recommend low to moderate-intensity exercise, as it benefits both systolic and diastolic blood pressure (Lopes et al., 2020).

Our study observed that regular physical activities of mild to moderate intensity can reduce the risk of hypertension-related complications and enhance overall health outcomes in older adults. Implementing effective interventions, such as promoting low to moderate-intensity physical exercise to manage blood pressure, can potentially reduce healthcare costs associated with hypertension and cardiovascular disease in older adults (Ghodeshwar et al., 2023). The concept that both systolic and diastolic blood pressure would decrease in older individuals after a single session of low to moderate-intensity exercise has significant implications in various domains (Chobufo et al., 2020). Healthcare professionals should advocate for utilizing readily available and manageable exercise intensities to regulate blood pressure in older individuals. Theoretically, providing insights into the influence of exercise on cardiovascular control through the rebound effect may be an avenue for healthcare professional to promote. Regarding policy, it would be advisable to advise public health recommendations and community projects to give top priority on stressing the advantages of engaging in physical exercise at this particular degree of intensity. Therapeutically, adequate intensity of exercise programs gives healthcare professionals hope in their effectiveness. From an educational standpoint, it is crucial to offer substantial resources for training and patient education programs in order to enhance awareness about the benefits of exercise. Highlighting the cost-effectiveness of encouraging low to high-intensity exercise to lower healthcare costs linked to high blood pressure is important from an economic point of view. To summarize, this research improves our understanding of how low to moderate-intensity exercise can effectively improve cardiovascular health in older adults.

Our hypothesis 3 results demonstrated no statistically significant difference in post-exercise blood pressure response between 65-year-old men and women following a single low- or moderate-intensity exercise session. To effectively manage blood pressure, it can be helpful to use exercise guidelines that are not specific to either gender. Developing plans and standards for vector size is made easier by uniformly applying these requirements to both senior males and females. Fitness specialists should consider creating workouts without gender or blood pressure changes. This methods enables the execution of collective workout sessions in community and healthcare environments. The gender and cardiovascular response research show that gender-specific cardiovascular responses to exercise are not significantly different which his may contradict gender-specific cardiovascular response theories (Bassareo et al., 2020). Gender-specific exercise training has the potential to initiate a reevaluation of how gender influences immediate cardiovascular reactions to physical activity. Including both men and women in health policies can successfully encourage older people of both sexes to exercise, which can have important policy effects (Sims-Gould et al., 2019). To improve the cardiovascular health of older people, this encourages the use of methods that include everyone. The results of our study suggest that more thorough research is needed to fully understand the long-term effects of physical activity, taking into account varying degrees of intensity and duration, in order to look into any gender disparities that might develop over time.

The clinical implications of this study are providing standardized exercise guidelines for managing blood pressure in older persons of both genders. Recognizing that both genders have similar reactions can encourage more older people to join fitness programs to lower blood pressure and improve cardiovascular health. This study suggests that health and fitness training programs should emphasize that older men and women have similar blood pressure responses to exercise. Promoting exercise in older individuals can reduce hypertension-related problems and save healthcare costs.

The concept that there is no statistically significant difference in the post-exercise blood pressure reaction between males and females aged 65 and older following a session of low to moderate-intensity exercise has significant implications. The implementation of effective interventions for senior individuals is streamlined by the development of exercise guidelines and programs that are inclusive of all genders. Theoretically, the treatments cast doubt on conventional wisdom on the ways in which gender affects cardiovascular responses to physical activity by pointing to potential similarities in the underlying physiological pathways. Its policy promotes comprehensive health planning and resource efficiency. The organization's approach promotes comprehensive health planning and resource efficiency. Constant exercise advice from a clinical perspective may increase physical activity. This emphasizes gender equality in training and patient education. Study shows how non-gender-specific fitness regimens can save money and reduce healthcare expenditures. This research explains how physical activity affects blood pressure in elderly people of all genders. Effective and equitable healthcare interventions are made possible. The dissertation can provide a deep understanding and practical recommendations beyond the research results by examining these effects.

Limitations

The limitations include that participants were asked to participate in a single exercise and would hold more credibility if multiple exercise bouts were performed. Another limitation was that the measurement of post-exercise blood pressure was conducted 30 minutes after the exercise session, so imposing a limitation. Following the completion of the exercise session, a heightened blood pressure response from the study participants may be observed for an extended duration. The body's shift from an acute response to a more stable recovered condition is primarily responsible for the variations in blood pressure measured at 30 minutes compared to 2 hours. After 30 minutes, the body frequently continues to respond to a stimulus, resulting in temporary fluctuations in blood pressure. After two hours, blood pressure measures usually show a more stable physiological state and these first reactions usually fade. Comprehending these mechanisms is essential for precise analysis of blood pressure data and for making well-informed choices regarding cardiovascular well-being. As the formula used to evaluate the difference between BP levels pre- and post-exercise (post-exercise BP) does not cover possible changes in BP that can occur independently of exercise (i.e., circadian effects), in the present study we cannot deduce about post-exercise hypotension (Lopes et al., 2020). A control session should has been used to determine post-exercise hypotension, which is a limitation of the study. Selection bias was possible because some participants who volunteered for the study were more health-conscious or physically active than the general older adult population, potentially skewing the results. Various factors, including the time of day, stress levels, and recent activities may have influenced the blood pressure measurement, limiting the accuracy of our results.

Our study lacked a control group since it would be challenging to identify a suitable one that does not exercise but is otherwise similar to the intervention group, therefore compromising the validity of the study. The lack of a well-matched control group may have limited our study's ability to attribute changes in blood pressure specifically to the exercise intervention. The duration of our study was short, limiting our ability to capture the long-term effects of exercise on blood pressure. Conversely, long-term studies may face issues with participant retention and adherence. Mental health and motivation levels of our patients may have limited participation in outcomes, but these factors are difficult to control or measure accurately. Walks, bikes, and strength training are all different types of exercise that might have different effects. Also, the study's results might not be true for all types of low to moderate-intensity exercise. Addressing these limitations in the dissertation will strengthen the study's credibility and provide a clearer context for interpreting the findings. Acknowledging these limitations also offers directions for future research to build upon the study's results.

Recommendations for Future Research

Subsequent investigations in this field are necessary with the goal of developing appropriate exercise regimens to improve knowledge of the blood pressure response during exercise in older adults. To accomplish this goal, additional works in the field of connected literature must be ascribed and analyzed. A longitudinal research study to assess the long-term effects of low to moderate-intensity exercise on blood pressure is recommended. Provide vital information about the long-term effects of exercise habits on cardiovascular health. Expanding the study's scope to include a diverse group of older persons from varied demographic backgrounds, will take into account factors such as socioeconomic status and preexisting health issues and increase the findings' applicability to other population groupings. Investigate the physiological factors behind blood pressure responses to low- and moderate-intensity exercise.

Examining changes in vascular function, autonomic modulation, and inflammatory markers is need in future research as well as assessing the effects of low- to moderate-intensity exercise on other therapy, such as dietary changes, medications, and high-intensity exercise. Examining several types of physical activity, such as aerobics, weight training, and flexibility exercises, will be the most beneficial aspect for regulating blood pressure in older adults. Investigating techniques for increasing older adults compliance with low to moderate-intensity exercise programs, will have an influence of peer support, technology, and tailored interventions. Assessing the impact of low to moderate-intensity physical activity on functional outcomes such mobility, balance, quality of life, and blood pressure needs to be apart of future research. Future research should concentrate on the mechanisms that induce identical blood pressure fluctuations in elderly men and women during physical activity.

Future research investigation should better understand how low—to moderate-intensity exercise affects older adults' blood pressure reactions. This can result in the creation of more effective solutions specifically designed for individual needs. The relationship between exercise intensity and older individuals is inconclusive and mostly uninvestigated. Moreover, a dearth of thorough exploration remains into the processes and physiology underlying the blood pressure reaction to physical activity. Hence, additional investigation is necessary to have a more comprehensive understanding of this reaction. Validating the hypothesis would encourage additional exploration into the long-term effects of various exercise intensities on blood pressure and overall cardiovascular health in senior adults. Further studies could examine the effects of low-intensity and high-intensity exercise on several health measures, such as lipid profiles, glucose metabolism, and cognitive function. These findings may spur further research into how exercise intensities affect older adults' blood pressure and other cardiovascular outcomes.

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