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EFFECTS OF AEROBIC EXERCISES ON FASTING BLOOD GLUCOSE AND BLOOD PRESSURE IN PATIENTS WITH TYPE 2 DIABETES LIVING WITH HYPERTENSION IN GHANA

A research dissertation submitted in fulfillment for the requirements for the degree Masters in Physiotherapy

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21ST December 2021

DECLARATION

With the exception of duly acknowledged references, I BRIDGETTE OPOKU, declare that this dissertation entitled "**Effects of aerobic exercises on fasting blood glucose and blood pressure in patients with Type 2 diabetes living with Hypertension in Ghana"** is my own work. It is submitted in fulfilment towards the master's degree in Physiotherapy at the university of Pretoria. It has not been submitted before for any degree or examination at this or any other institution.

Ms. B Opoku ………………………………………………... 21ST December 2021

DEDICATION

This research is dedicated to my family. They have been my backbone through it all. Their prayers, guidance and support brought me this far. Also, to my best friend Sean Abbey and his family. You are a great gift to me.

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To HIM who sits on the throne and radiates in splendor and in glory, all wisdom, glory and honor and thanksgiving unto His name.

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All the other people who urged me on, May God reward all your efforts with your heart's desires.

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LIST OF ABBREVIATIONS / ACRONYMS

Abbreviation / Acronym	**Meaning**
ACSM	American College of Sports Medicine
ADVANCE	Action in Diabetes and Vascular Disease Controlled Evaluation
ATP	Adenosine triphosphate
DM	Diabetes Mellitus
DALY	Disability-adjusted life years
Dbp	Diastolic blood pressure
Dbp A	Diastolic blood pressure after exercise
Dbp B	Diastolic blood pressure before exercise
FBG	Fasting blood glucose
Fbg A	Fasting blood glucose after eight weeks of intervention
Fbg B	Fasting blood glucose before intervention
FFAs	Free fatty acids
GBD	Global burden of disease
HbA1c	Glycated Haemoglobin
HOT	Hypertension Optimal Treatment
HTN	Hypertension
KBTH	Korle Bu Teaching Hospital
Mm/hg	Millimetres of Mercury
NDMRC	National Diabetes Management and Research Centre
NCDs	Non-communicable diseases

SBP	Systolic blood pressure
SBP A	Systolic blood pressure after exercise
SBP B	Systolic blood pressure before exercise
SNPs	single nucleotide polymorphisms
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
6MWT	6-minute walk test
UKPDS	United Kingdom Prospective Disease Study
WHO	World Health Organization

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ABSTRACT

Introduction: Diabetes and hypertension are associated with an increased risk of cardiovascular diseases. According to the National Diabetes Management and Research Centre, about one out of every two patients diagnosed with Type 2 Diabetes (T2DM) in Ghana has hypertension. Effective interventions are needed to resolve the burden of individuals with type 2 diabetes living with hypertension. Although pharmacological treatments can be costly and necessary for treating some blood pressure conditions, lifestyle modifications could also be implemented.

Aim: To determine the effects of aerobic exercises on fasting blood glucose and blood pressure in patients with type 2 diabetes living with hypertension consulting as outpatients at the National Diabetes Management and Research Centre in Korle Bu hospital, Accra, Ghana.

Method: An experimental design using single arm-controlled trial was undertaken.
Both males and females above 18-years of age, consulting as outpatients at the National Diabetes Management and Research Centre in Korle Bu hospital, Accra were recruited to participate in this study. Fasting blood glucose samples, anthropometric measurements and a distance walked using a six-minute walk test (6MWT) were measured at baseline and at two months (at the end of the intervention). Blood pressure measurements were taken on the day of exercise, before and after exercise. The intervention consisted of a 12 to 20 minutes of brisk walking three times a week, excluding weekends for a period of eight weeks (two months). Time was increased from 12 to 15 minutes in the fifth and sixth weeks, then from 15 to 20 minutes in the seventh and eighth weeks respectively. Data was analysed using STATA series 11 statistical package. Data were summarised with descriptive statistics, such as mean and standard deviation at 95% confidence interval limit. A paired t-test was used to compare baseline measurements of fasting blood glucose and at the end of eight weeks of aerobic exercise. Similar analysis was employed for blood pressure levels and 6MWT. Inferential statistics was used to establish the associations between age and changes in fasting blood glucose levels and blood pressure. Testing was done at the 0.05 level of significance.

Results: There were 52(87%) females and 8(13%) males. Forty-eight (n=48) of these participants were diagnosed with T2DM before hypertension (80%) whilst twelve (n=12) of them were diagnosed with hypertension first before T2DM (20%). There was a statistically significant reduction of fasting blood glucose and blood pressure levels with a decreased rate of perceived exertion (RPE) between baseline and post intervention measurements. Waist-hip ratio decreased by 0.01 and this change was also statistically significant, $p<0.05$.

Significance of study: Aerobic exercise such as brisk walking may improve the quality of life of patients living with T2DM and hypertension. This study has shown that brisk walking reduces the levels of fasting blood glucose which may help to reduce morbidity and mortality rates in this group of patients.

Conclusion: Aerobic exercises consisting of eight weeks of brisk walking reduced the levels of fasting blood glucose and blood pressure in patients with T2DM who are living with hypertension.

Key terms: Type 2 diabetes; Hypertension, Aerobic exercise, Fasting blood glucose comorbidity.

CHAPTER 1

INTRODUCTION

1.1 Background

Diabetes Mellitus (DM) is a chronic, debilitating metabolic disease characterised by chronic hyperglycaemia and disturbance of carbohydrate, fat and protein metabolism (Jackson, Adibe, Okonta and Ukwe, 2014). This is caused by defects in insulin secretion and insulin action resulting in a long-term damage and dysfunction of various organs such as the eyes, kidneys, nerves, heart and blood vessels. The most common type of DM is type 2 diabetes (T2DM), which affects 90% of adults and occurs when the body becomes resistant to insulin or doesn't produce enough of insulin (Roglic, 2016). T2DM is an independent risk factor for both micro vascular diseases such as retinopathy and nephropathy as well as macro vascular disease such as myocardial infarction and stroke (Bolli, 2018). T2DM is also associated with other cardiovascular disease risk factors, including hypertension, obesity, lack of physical activity, smoking and family history (Bolli, 2018). Development of cardiovascular diseases contributes to the morbidity and mortality of patients with DM (Cryer, Horani and DiPette, 2016).

Hypertension is also a major risk factor for cardiovascular diseases and its prevalence is increasing in DM. Studies have shown that patients with diabetes have twice the chance of developing hypertension than those without diabetes (Gillespie and Hurvitz, 2013; Grundy, Garber, Goldberg, Havas, Holman, Lamendola et al., 2002). Patients with DM experience increased peripheral artery resistance caused by vascular remodeling and increased body fluid volume associated with insulin resistance induced hyperinsulinemia and hyperglycaemia. Both mechanisms elevate systemic blood pressure (Fujihara and Sone, 2018). Detection and management of elevated blood pressure (BP) is a critical component of the comprehensive clinical management of DM (Cryer et al., 2016). A multidisciplinary approach is the ideal and efficient approach to the management of patients with T2DM and hypertension. It is therefore assumed that multidisciplinary treatment should be extended to patients with both T2DM and hypertension, however there is lack of adequate literature to support this hypothesis of extension of services to patients with both diabetes and hypertension (Jardim, Inuzuka, Galvão, Negretto, de Oliveira, Sá. 2018). The management of T2DM and hypertension include, pharmaceutical (medications) treatment, diet as well as physical activity.

The World Health Organization (WHO) defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure (WHO, 2019). Exercise is physical activity that is a planned, structured movement of the body designed to enhance physical fitness (Fagard, 2011). Exercises can be classified into aerobic and anaerobic exercises. Aerobic exercises involve large muscles in the body such that large amounts of oxygen are required as energy expenditure (Colberg, Sigal, Yardley, Riddell, Dunstan, Dempsey, 2016). Regular aerobic exercise has a variety of effects that protect against heart disease and other diseases of the blood vessels, including hypertension. On average, exercise reduces blood pressure by six to 7mmHg (Ali and Bakris, 2019). Studies with large numbers of participants have shown that a five (5) mmHg reduction of SBP results in 14% decrease of deaths from strokes and a nine percent (9%) decrease of deaths from coronary heart diseases (Lobelo, Stoutenberg and Hutber, 2014; Geneen et al., 2014). Studies have shown consistently that aerobic exercise reduces systolic and DBP in patients with essential hypertension (Patel, Alkhawam, Madanieh, Shah, Kosmas and Vittorio, 2017; Colberg et al., 2016; Geneen et al., 2014; Kearney, Whelton, Reynolds, Whelton and He, 2004). There is evidence that aerobic training helps to reduce blood pressure in patients with hypertension (Goldhammer, Tanchilevitch, Maor, Beniamini, Rosenschein and Sagiv, 2005). Patients with diabetes who took part in supervised exercises recorded long-term improvements in blood glucose control and insulin sensitivity than those who engaged in home exercises that were not supervised (Way, Hackett, Baker and Johnson, 2016; Dunstan, Mori, Puddey, Beilin, Burke, Morton et al., 1997). Aerobic or resistance training is related to statistically significant improvements in glycemic control (Geneen et al., 2014). The above submissions therefore support the importance of emphasising the need of aerobic exercises for patients with T2DM and hypertension. It is vital that effective interventions are advocated to reduce overall morbidity and mortality. Although pharmacological treatments can be costly and necessary for treating some blood pressure conditions, lifestyle modifications could also be implemented.

There has been an increase in the preponderance of DM over the past 40 years worldwide (Bharati, Tauro, Rawat, Sharma and Shrivastav, 2012). The international diabetes federation (IDF) estimates that about 450 million people are living with diabetes, with 5.1 million dying from the condition annually worldwide (Athyros, Ganotakis, Elisaf and Mikhailidis, 2005). Ghana has a significant diabetes burden with a profile like that of other African countries (Hall, Thomsen, Henriksen and Lohse, 2011).

With current research relating the occurrence of hypertension with diabetes and beneficial effects of exercise in both diseases (Paing, McMillan, Kirk, Collier, Hewitt and Chastin, 2018; Faselis, Doumas, Pittaras, Narayan, Myers, Tsimploulis, 2014), it will be interesting to know how aerobic exercise specifically affects blood glucose and blood pressure which are primary indicators of diabetes and hypertension respectively. Empirical evidence shows that physiotherapy has not been fully explored in the management of patients with T2DM living with hypertension in Ghana.

1.2 Problem Statement

There is an increase in the number of patients diagnosed with T2DM living with hypertension comorbidity (Danquah, Bedu-Addo, Terpe, Micah, Amoako, Awuku, 2012) in Ghana. According to the National Diabetes Management and Research Centre (NDRMC), about one out of every two patients diagnosed with T2DM in Ghana has hypertension. This is due to the inconsistent availability of medications and the non-implementation of the use of a multidisciplinary approach to the management of diabetes patients living with hypertension. Management of patients with diabetes and hypertension in Ghana focuses only on medication (Lotsu, Kwakye, Mohammed, Opoku, Quartey and Lawson, 2021; Bello, Owusu-Boakye, Adegoke and Adjei, 2011). Even though evidence shows that exercises may be useful in the management of these patients, there is still insufficient information regarding the effect of exercises on patients with T2DM living with hypertension in various low- and middle-income countries such as Accra, Ghana (Osei-Yeboah, Owiredu, Norgbe, Obirikorang, Lokpo, Ashigbi et al., 2019) . It has also been shown that DM has been increasing in Ghana yet few health professionals, drugs and equipment exist to manage it (Darkwa, 2011). It is therefore essential to investigate the effect of aerobic exercises on fasting blood glucose and blood pressure in individuals with T2DM and hypertension. The inclusion of exercise is likely to reduce the costs involved with the use of pharmacological drugs in managing these patients in Accra, Ghana, as well as improve their quality of life.

1.3 Research Question

What is the effect of aerobic exercises on blood glucose levels and blood pressure in patients with type 2 diabetes living with hypertension?

1.4 Aim

To determine the effects of aerobic exercises on fasting blood glucose and blood pressure in patients with type 2 diabetes living with hypertension consulting as outpatients at the National Diabetes Management and Research Centre in Korle Bu hospital, Accra, Ghana

1.5 Objectives

1. To determine the socio-demographic characteristics of patients with type 2 diabetes and hypertension.
2. To determine the fasting blood glucose levels before and after exercise in patients with type 2 diabetes and hypertension.
3. To determine the blood pressure levels before and after exercise in patients with type 2 diabetes and hypertension.
4. To determine the association between age and changes in levels of fasting blood glucose and blood pressure in patients with type 2 diabetes and hypertension.

1.6 Hypothesis

- ***Null hypothesis***: An eight (8) weeks' aerobic exercise intervention will not reduce the fasting blood glucose and blood pressure levels in patients with type 2 diabetes and hypertension.
- ***Alternative hypothesis***: An eight (8) weeks' aerobic exercise intervention will cause a 1.8% reduction in the levels of fasting blood glucose and blood pressure in patients with type 2 diabetes and hypertension, thereby improving their quality of life.

1.7 Definitions of key Terms

- **Type 2 Diabetes (T2DM):** It is a chronic disease caused by a defect in the secretion of pancreatic insulin and/or an insensitivity of target tissues to its actions leading to hyperglycemia contributing to morbidity and mortality (Eliasson, Liakopoulos, Franzén, Näslund, Svensson, Ottosson, 2015). In this study, T2DM was diagnosed by medical doctors at the NDRMC and information was obtained from each patient's case records.

- **Fasting Blood Glucose (FBG)**: The glycemic status obtained from the laboratory results after an overnight fasting with a range of 4 to 6mmol/l (ADA, 2015). In this study, it was used to determine the FBG levels of the participants.

- **Hypertension**: A systolic blood pressure ≥ 130mmHg or diastolic blood pressure is ≥ 80mmHg on each of two successive readings obtained by the clinic physician (Gillespie et al., 2013). For this study all patients diagnosed with T2DM and had a systolic pressure above 135 mmHg with a diastolic pressure of more than 85mmHg were considered living with hypertension.

- **Physical Activity:** The World Health Organization defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work. Both moderate- and vigorous-intensity physical activity improve health (WHO, 2019). For the purposes of this study, physical activity entails aerobic exercises**.**

- **Aerobic Exercise**: are exercises that involve large muscles in the body such that large amounts of oxygen are required for energy (Colberg et al., 2016). The aerobic exercise protocol complied with the American College of Sports Medicine Guidelines (ACSM) (American College of Medicine Position Stand 1990), and includes treadmill walking or jogging, stair-stepping, stationary cycling and brisk walking. For the purposes of this study, aerobic exercise refers to brisk walking.

- **Brisk walking**: is considered a moderate-intensity, low-impact workout that does not exert excess strain on joints (hip, knee, ankles) that are susceptible to injury with higher-impact workouts. It is either slow or quite speedy for others, depending on the levels of fitness. One measure to quantify brisk walking is "steps per minute," and 100 steps per minute is considered moderate intensity or brisk walking (Shatil, 2013). For this study, brisk walking is moderate intensity workout where participants walked quite speedily at the start time and slowly when tired.

1.8 Assumptions

- Patients diagnosed with T2DM and hypertension have increased levels of fasting blood glucose and blood pressure
- Patients who visited the NDMRC came fasting on the day of first assessment and the last day of the intervention.

1.9 Delineation

The study targeted all outpatients diagnosed with T2DM and hypertension who consulted at the National Diabetes Management and Research Centre, Korle Bu Teaching Hospital (KBTH).

1.10 Significance / Contribution

Knowledge about the effects of aerobic exercises as an adjunct in the reduction of fasting blood glucose and blood pressure levels of patients living with T2DM and hypertension may assist physiotherapists in developing and prescribing the correct aerobic exercise protocols for them. This evidence will help healthcare professionals to include aerobic exercises in their treatment protocols and not only rely on pharmacological drugs, since diabetes and hypertension will eventually affect the muscles, nerves and tissues of the patients. Patients with good understanding about the effects of aerobic exercises on their condition will be motivated to participate in activities such as walking to help curb their physical limitations, improve their quality of life and restore function. This will improve the general wellbeing of patients living with T2DM and hypertension. Aerobic exercises are known to improve blood glucose levels and hypertension; hence this study may help reduce morbidity and mortality rates. A multidisciplinary approach is the ideal and efficient approach to the management of patients with T2DM and hypertension, hence the inclusion of exercise is likely to reduce the costs involved with the use of pharmacological drugs.

1.11 Outline of Study

This study will be organised into six different chapters. These include:

Chapter 1: Introduces the study with adequate background information about T2DM and hypertension, physical activity and exercises, the problem in Ghana, the aim, objectives and significance of the study.

Chapter 2: Literature review: Discusses literature related to the pathophysiology of T2DM and Hypertension; effects of aerobic exercises on fasting blood glucose and blood pressure of patient with Type 2 Diabetes (T2DM) living with hypertension.

Chapter 3: Methodology: The general overview of the research design, the study setting, study population, inclusion and exclusion criteria are presented. The sampling method, sample size, instruments used for data collection, measures to enhance quality control and data analysis are described and presented.

Chapter 4: Results: The results obtained from analysing the data are first presented descriptively in terms of the participant profile. This is followed by a presentation of the study variable measurements in terms of descriptive and inferential statistics of mean comparisons and correlations.

Chapter 5: Discussion: The findings of this study are discussed in relation to the aim and objectives of the study.

Chapter 6: Conclusion, Limitations and Recommendations: The study is concluded with Limitations of the study stated and recommendation given.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The previous chapter introduced the study and focused on the overview dissertation. This chapter will discuss literature reviewed related to the pathophysiology of T2DM and Hypertension; effects of aerobic exercises on fasting blood glucose and blood pressure of patient with Type 2 Diabetes (T2DM) living with hypertension.

2.1.1 Search Strategies

A literature review on the topic effects of aerobic exercises on fasting blood glucose and blood pressure of patients with T2DM living with hypertension in Accra, Ghana was conducted using the following search engines; Scopus, Google Scholar, PubMed and Science Direct. Thesis and dissertations from University of Ghana and full text English research articles which contained a comprehensive investigation of human adults from 1995 to 2021 were included. Only studies focusing on T2DM and Hypertension were included in the literature review. The literature search was conducted between February 2019 to April 2021. The following keywords were used for the search: Diabetes Mellitus, Type 2 Diabetes, Hypertension, Fasting blood glucose, blood pressure, physical activity, physical exercise, and aerobic exercise. Keywords were separated and combined by using the words “AND” and “OR” during the literature search. Two hundred articles were downloaded and of these 80 relevant articles were read and included in the literature review.

2.1.2 Purpose of the Literature Review

The purpose of the literature review was to provide a comprehensive background on the effects of aerobic exercises on fasting blood glucose and blood pressure of T2DM patients living with hypertension. The literature reviewed also aimed at identifying gaps in literature, in order to make justification for the current study. The literature review will be focused on the following subtopics:

- T2DM and its management,
- Hypertension and its management,
- The association between T2DM and Hypertension,
- The effects of exercise on T2DM and Hypertension.

2.2 Diabetes Mellitus

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both (Mellitus and Prevention, 2007). The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of different organs, especially the eyes, kidneys, nerves, heart, and blood vessel (Mellitus et al., 2007). Several pathogenic processes are involved in the development of diabetes. These range from autoimmune destruction of the pancreatic β-cells with consequent insulin deficiency to abnormalities that result in resistance to insulin action. The basis of the abnormalities in carbohydrate, fat, and protein metabolism in diabetes is deficient action of insulin on target tissues (Association, 2007). Diabetes mellitus can be classified generally into four categories (Association, 2007):

- Type 1 diabetes (T1DM) is due to autoimmune β-cell destruction usually leading to absolute insulin deficiency (De Boer, Bangalore, Benetos, Davis, Michos, Muntner, 2017), this type is also referred to as the early childhood diabetes mellitus. It accounts for 5 - 10% of the total cases of DM and it will not be discussed further in this study.
- T2DM is due to progressive loss of β-cell insulin secretion frequently on the background of insulin resistance. It accounts for 90-95% of the total cases of DM. This type will be discussed further in this study, together with hypertension.
- The third type; Gestational diabetes (GDM) is mostly found amongst pregnant women in their second or third trimester that was not clearly overt diabetes prior to gestation (Chatterjee, Khunti and Davies, 2017).
- The fourth type are specific types of diabetes which is usually due to other causes e g, monogenic diabetes syndromes such as neonatal diabetes and maturity onset of the young (De Boer et al., 2017). According to the current classification there are two major types: Type 1 diabetes (T1DM) and Type 2 diabetes (T2DM) (WHO, 2018).

Globally the number of individuals with diabetes mellitus has quadrupled in the past three decades and diabetes mellitus is the ninth major cause of death worldwide (Zheng, Ley and Hu, 2018). One in 11 adults worldwide have diabetes mellitus, of whom 90% are T2DM (Zheng et al., 2018). T2DM is a chronic metabolic disorder that results from defects in both insulin secretion and insulin action (Zheng et al., 2018; DeFronzo, Ferrannini, Groop, Henry, Herman, Holst et al., 2015; 1999). It is characterized by progressive deterioration of glucose tolerance (Ley, Schulze, Hivert, Meigs and Hu, 2018) and relative insulin deficiency caused by pancreatic β-cell dysfunction and insulin resistance in target organs (Chatterjee et al., 2017). T2DM is a heterogeneous disease involving multiple behavioral, metabolic and genetic factors (Ley et al., 2018). T2DM is an expanding global health problem closely linked to the epidemic of obesity (DeFronzo et al., 2015). Between 1980 and 2004, the global rise in obesity, sedentary lifestyles, and an ageing population have quadrupled the incidence and prevalence of T2DM (Chatterjee et al., 2017). A study conducted in Cape coast, Ghana showed that DM has been increasing since 2005 yet few health professionals, drugs and equipment exist to manage it (Darkwa, 2011). Changing dietary patterns and lifestyles was found to be associated with the upsurge of DM. In Accra alone, the prevalence was 15% in 2015 (Kumah, Akuffo, Abaka-Cann, Affram and Osae, 2015). Individuals with T2DM are at high risk for both microvascular complications such as retinopathy, neuropathy, nephropathy and macrovascular complications including cardiovascular comorbidities (Chatterjee et al., 2017; DeFronzo et al., 2015). Cardiovascular disease is the greatest cause of morbidity and mortality associated with T2DM (WHO, 2018). Intensive management of glucose, and lipid concentrations as well as blood pressure are needed to minimize the risk of complications and disease progression (Chatterjee et al., 2017).

Measurement of Plasma glucose concentration after overnight fast or after glucose loading has been fundamental for diagnosing diabetes in the past century (Bartoli, Fra and Schianca, 2011). In 1997, the American Diabetes Association amended the known criteria to diagnose diabetes by lowering the Fasting blood glucose level (126 mg/dl for diabetes) (Bartoli et al., 2011). Blood glucose binds in an irreversible manner to circulating hemoglobin in red blood cells (RBCs), generating "glycated hemoglobin," called HbA1c. The Glycated hemoglobin (HbA1c) is another method used to diagnose T2DM and to assess glycemic control in patients with diabetes (Wheeler, Leong, Liu, Hivert, Strawbridge, Podmore et al., 2017). Apart from the efficacy of HbA1c in detection of diabetes, it is an important marker to assess the microvascular complications and plasma glucose (Ghazanfari, Haghdoost, Alizadeh, Atapour and Zolala, 2010). In the randomized controlled study conducted by Ghazanfari et al., in 2010, It was concluded that HbA1c is relatively strongly associated with fasting blood glucose (FBG) particularly in patients with diabetes. FBG was a more accurate predictor for HbA1c (Ghazanfari et al., 2010).

Globally, diabetes prevalence is similar in men and women but is slightly higher in men less than 60 years of age and in women at older ages (Ogurtsova, da Rocha Fernandes, Huang, Linnenkamp, Guariguata, Cho et al., 2017). In developing countries, majority of people diagnosed with diabetes fall in the 45 years to 64-years age range (Guariguata, Whiting, Hambleton, Beagley, Linnenkamp and Shaw, 2014). This is in contrast to developed countries where the majority of people with diabetes are greater than 64 years of age. By 2030, it is estimated that the number of people with diabetes greater than 64 years of age will be over 82 million in developing countries and over 48 million in developed countries (Wild, Roglic, Green, Sicree and King, 2004). The study conducted in 2002 on the total prevalence of diabetes among people aged 20 years or older in the

United States of America showed that 18 million (which is 8.7%) of all people above 20-years of age had diabetes and 8.6 million (18.3%) of all people above 60-years had diabetes. In this population, 8.7% of all men aged 20-years or older had diabetes as well as 9.3% of women (Control and Prevention., 2008). Other studies have shown that Individuals aged 55 years or older have a 90% chance of developing hypertension, and approximately 70% of patients with diabetes over the age of 40-years also have hypertension (Mancia, 2005; Shaikh, 2017). More than two-thirds of the rise in the prevalence of diabetes is expected in low- and middle-income countries, including those in sub-Saharan Africa (Wild et al., 2004). The burden of the disease in Africa has risen significantly from an estimated 7.1 million people in the early 2000s to an estimated 18.6 million by 2030. Trends in the prevalence of diabetes in Ghana do not differ significantly from those observed in other sub-Saharan African countries, with earlier studies showing a meagre prevalence rate of less than 0.02% of the adult population and recent figures ranging from 6.2% to 13.9% (Asamoah-Boaheng, Sarfo-Kantanka, Tuffour, Eghan and Mbanya, 2019).

In Ghana, diabetes and hypertension are major health challenges (Duah, Nsiah and Agyeman-Duah, 2017). Diabetes was reported in over 354,000 adults, aged 20-79 in 2012 and 6,973 deaths were recorded as a result. It is further estimated that over 292,450 people in Ghana have undiagnosed diabetes (Atlas, 2015). Besides genetic factors, behavioural risk factors such as eating foods high in salt and fat, inadequate intake of fruit and vegetables, harmful use of alcohol use, tobacco smoking, low physical activity and poor stress management contribute to the development of hypertension (WHO, 2013). Older age and overweight/obesity appear to be consistent determinants of hypertension in patients with DM (Bosu, Reilly, Aheto and Zucchelli, 2019). Analysis of household survey data in five sub-Saharan Africa countries (Benin, Burundi, Ghana, Kenya and Lesotho) showed that women with overweight or obesity were 2.4 and 5.3 times as likely as those with normal body mass index (BMI) to have hypertension in patients with DM (Yaya, Uthman, Ekholuenetale and Bishwajit, 2018). Overweight/obesity, physical inactivity, older age and family history of diabetes are also significantly associated with adult DM in Ghana (Asamoah-Boaheng et al., 2019).

There is an increasing prevalence of T2DM in the adult population, which stood at 3.35% by the end of 2013 (Kumah et al., 2015). About 8000 deaths were reported from diabetes in 2013. A three-year study conducted in Accra indicated that six percent of the people in Kumasi and 9% of the people in Accra had T2DM (Danquah et al., 2012). This study also revealed risk factors such as advanced age, obesity, family history of DM, smoking and alcohol, lack of physical activity, poor nutrition during pregnancy, ethnicity and low-income levels (Danquah et al., 2012). Studies revealed glucose abnormalities in people who smoke. It was concluded that smoking is a modified risk of T2DM (Bello et al., 2011; Hall et al., 2011; Sowers, Epstein and Frohlich, 2001). Diabetes Mellitus has an impact on the working population since most of the patients are between the ages of 20 years and 60 years. It can affect many organ systems. It can cause acute and chronic complications. These complications are serious health problems resulting in deterioration of the quality of life and premature death (Priya, 2013). In patients with T2DM, prevalence of hypertension is more than twice the population of patients without DM which is largely due to clustering of both disorders in patients with obesity and insulin resistance (Shervin, 2004). Approximately two-thirds of adults with diabetes have hypertension (Lawrence, Stephen and Maxine, 2005).

2.2.1 Insulin Resistance

Insulin is a hormone that plays a fundamental role in the development of hypertension among patients with T2DM, and the metabolic syndrome. The main metabolic actions of insulin are to stimulate glucose uptake in skeletal muscles and the heart. Insulin also suppresses the production of glucose and very low-density lipoprotein (VLDL) in the liver (Ribeiro-Oliveira, Nogueira, Pereira, Boas, dos Santos and De Silva, 2008). Under fasting conditions, insulin secretion is suppressed, leading to increased glucose synthesis in the liver and kidneys from a non-starch substrate, such as fat or protein (glucogenolysis) and increased conversion of glycogen to glucose in the liver (glycogenosis) (Jellinger, 2007). After a meal, insulin is released from pancreatic β-cells and inhibits gluconeogenesis and glycogenolysis (Jellinger, 2007). Insulin stimulates the sympathetic nervous system (SNS) to increase cardiac output and the delivery and utilisation of glucose in the peripheral tissues (Ripley and Saseen, 2014). Other metabolic effects of insulin include inhibition of glucose release from the liver, inhibition of the release of free fatty acids (FFAs) from adipose tissue, and stimulation of the process by which amino acids are incorporated into protein (Jellinger, 2007). Most patients with type 2 diabetes are insulin resistant, and about half of those with essential hypertension are insulin resistant (Reaven, 2011). Therefore, insulin resistance is an important common link between diabetes and hypertension. Literature confirmed that insulin-resistant subjects display a blunted sympathetic neural response to glucose ingestion compared with age- and blood pressure-matched insulin-sensitive subjects, despite a 2-fold greater increase in plasma insulin concentrations (Straznicky, Lambert, Masuo, Dawood, Eikelis, Nestel, 2009). Antidiabetic pharmaceutical agents are used to manage type 2 diabetes; however, physical activity remains the mainstay in the management of this disease.

2.3 Hypertension

Hypertension is defined as a systolic blood pressure of more than 140 mm Hg or above, a diastolic blood pressure of more than 90mm Hg or above, or both (Akilen, Tsiami, Devendra and Robinson, 2010). Hypertension is classified as either primary (essential) or secondary hypertension. About 90% to 95% of cases are categorized as "primary hypertension" which means high blood pressure with no obvious underlying medical cause (Norlander, Madhur and Harrison, 2018). The remaining five percent (5%) to 10% of cases (secondary hypertension) are caused by conditions that affect the kidneys, arteries, heart or endocrine system (Norlander et al., 2018). Primary hypertension results from a complex interaction of genes and environmental factors. Several environmental factors influence blood pressure and these factors includes ambient temperature, altitudes, latitudes and air pollutants. Lifestyle factors that can lower blood pressure include increased physical activity, abstaining from alcohol and smoking, reduced intake of carbohydrate, meat and fat, reduced dietary salt intake (Meena, 2016; He, Li and MacGregor, 2013).

Hypertension is twice as common in patients with DM than in patients without this disease (Mancia, 2005), hence Controlling the blood pressure in people with DM have been extensively debated during the past decade. Patients want to be assured that blood pressure (BP) treatment will reduce their disease burden, while clinicians want guidance on hypertension management using the best scientific evidence. Guidelines have recommended treating patients to achieve a blood pressure of less than 130/80 mm Hg (Brunström and Carlberg, 2016). This was based on evidence from several vast studies, including the Hypertension Optimal Treatment (HOT) study, the United Kingdom Prospective Diabetes Study (UKPDS) 38 and the Action in Diabetes and Vascular Disease Controlled Evaluation (ADVANCE) trial (Patel, 2007; Grossman and Grossman, 2017).

During 2013 multiple hypertension guidelines were updated (James, Oparil, Carter, Cushman, Dennison-Himmelfarb, Handler et al., 2014; Weber, Schiffrin, White, Mann, Lindholm, Kenerson et al., 2014; Jennings and Touyz, 2013). The report took rigorous, evidence-based approach to recommend treatment thresholds, goals, and medications in the management of hypertension in adults. Evidence was drawn from randomized controlled trials, which represent the gold standard for determining efficacy and effectiveness. Evidence for quality recommendations were graded based on their effect on important outcomes (James et al., 2014; Jennings et al., 2013). There is strong evidence to support treating persons with hypertension aged 60 years or older to a BP goal of less than 150/90 mmHg and those aged 30 through 59 years to a diastolic goal of less than 90 mmHg. However, there is insufficient evidence in patients with hypertension younger than 60 years for a systolic goal, or in those younger than 30 years for a diastolic goal, so the panel recommends a BP of less than 140/90 mmHg for those groups based on expert opinion. These thresholds and goals are recommended for patients with both hypertension and diabetes (Mattioli, Sciomer, Moscucci, Maiello, Cugusi, Gallina *et al*., 2019; James *et al*., 2014).

Hypertension is the most important risk factor for mortality and developing cardiovascular disease worldwide (Brunström *et al*., 2016). Traditionally, a high burden of hypertension and its adverse consequences had been mistakenly thought to be an affliction of only economically developed countries (Pearson, 1999). However, studies over the past two decades had reported the majority of people in many economically developing countries had blood pressure above the levels considered optimal with a high prevalence of hypertension present (Hernandez-Hernandez, Armas-Padilla, Armas-Hernandez and Velasco, 2000; Singh, Suh, Singh, Chaithiraphan, Laothavorn, Sy et al., 2000; Gupta, 1999). World Health Organization first reported the global burden of disease (GBD) for 1990 using disability-adjusted life years (DALY), which is a time-based measure that combines years of life lost due to morbidity and premature mortality (Piercy, Troiano, Ballard, Carlson, Fulton, Galuska et al., 2018). The first GBD report found that the top five leading causes of death world-wide were ischemic heart disease, cerebrovascular accidents, lower respiratory infections, diarrheal disease, perinatal disorders and these conditions came as a result of hypertension (Abd Elwahaab, Rahmy, Hagag, Fares and Fouad, 2019). People with diabetes mellitus are at increased risk of cardiovascular disease and often have comorbid hypertension (Brunström *et al*., 2016). The use of pharmaceutical drugs with antihypertensive effects are recommended for lowering blood pressure and control at 140/90 mmHg. Exercises have been recommended in the control of Hypertension, however the effects of exercises as an adjunct to reduce the risk of cardiovascular disease in people with diabetes mellitus, is still debated (He, Wei and Can, 2018; Wen and Wang, 2017; Brunström *et al*., 2016). Also, the optimal effects of exercises to bring the SBP to an optimal level is unclear.

The magnitude of simultaneous prevalence of T2DM and hypertension depends on age, body mass index and ethnicity. In patients with T2DM, hypertension usually presents early and in combination with other cardiovascular risk factors (De Ferranti *et al*., 2014). Factors involved in the pathogenesis of both hypertension and type 2 diabetes include inappropriate activation of the renin-angiotensin-aldosterone system, oxidative stress, inflammation, impaired insulin-mediated vasodilatation, augmented sympathetic nervous system activation, altered innate and adaptive immunity, and abnormal sodium processing by the kidney (Norlander *et al*., 2018). There is a need to introduced evidence-based cost-effective strategies to manage patients with T2DM leaving with hypertension.

2.4 Association between Type 2 Diabetes and Hypertension

Hypertension and T2DM are major non-communicable diseases (NCDs) leading to catastrophic complications including death (Babu, Murthy, Ana, Patel, Deepa, Neelon, 2018). In the Hong Kong Cardiovascular Risk Factor Prevalence Study, only 42% of people with diabetes had normal blood pressure and only 56% of people with hypertension had normal glucose tolerance (Cheung, 2010). This study suggested that 58% of people with diabetes had hypertension whereas 44% of people with hypertension had diabetes. This implies that people who have T2DM are more likely to develop hypertension. In the US population, hypertension occurs in approximately 30% of patients with type I diabetes and in 50% to 80% of patients with type 2 diabetes (Landsberg and Molitch, 2004). A prospective cohort study in the United States reported that type 2 diabetes mellitus was almost 2.5 times as likely to develop in subjects with hypertension as in subjects with normal blood pressure (Gress, Nieto, Shahar, Wofford and Brancati, 2000). In Ghana, the prevalence of hypertension among patients with T2DM varies widely from 4.5% to 54.6% according to the Ghana Demographic and Health Survey and highest are found among urban dwellers (Tannor, Sarfo, Mobula, Sarfo-Kantanka, Adu-Gyamfi and Plange-Rhule, 2019). Hypertension and T2DM in these settings are under-recognized, untreated, or under-treated due to a combination of factors in developing countries (Boutayeb and Boutayeb, 2005; Tannor *et al.,* 2019).

The incidence of hypertension is increased in individuals with T2DM (Waeber, Feihl and Ruilope, 2001). The prevalence of hypertension in patients with T2DM is one and a half to three ($1^1/_2$ -3x) folds higher than in patients who do not have diabetes (Burlando, Sánchez, Ramos, Mogensen and Zanchetti, 2004). In patients with T2DM prevalence of hypertension is more than twice that of those who do not have diabetes (Priya D., 2013). Literature demonstrates that it is common to find diabetes and hypertension in the same individual more often than would occur by chance, whereas the overlap between dysglycemia and raised blood pressure is even more substantial than that between hypertension and T2DM (Cheung, 2008). The etiology of developing hypertension when living with diabetes is coherent with genetic and environmental factors (Cheung, 2010). A cross-sectional survey study, conducted to evaluate the association of blood pressure with fasting blood glucose levels in Northeast China, demonstrated that fasting glucose was positively associated with BP in men, but not in women (Lv, Yao, Ye, Guo, Dou, Shen et al., 2018). A Japanese scholar conducted a five (5) year cohort study to show that higher baseline blood glucose level was an independent risk factor for new onset hypertension regardless of women and men (Joshipura, Muñoz-Torres, Campos, Rivera-Díaz and Zevallos, 2018). However, some controversy regarding the relationship between fasting glucose levels and risk of onset of hypertension still occurs based on different adjustments covariates, such as age, obesity, lifestyle factors, and obesity measurements (Ghaffari and Roshanravan, 2020; Kim, Kim, Kim, Bae, Choe, Park et al., 2013).

Hypertension may be present at the time of the diagnosis and may even precede overt hyperglycemia (Burlando *et al*., 2004). In these patient's high blood pressure is common at the time of diagnosis of DM, but the development of diabetes is often preceded by a period during which hyperinsulinemia and insulin resistance is already present (Waeber *et al*., 2001). The development of hypertension in patients with T2DM coincides with the development of hyperglycaemia (Ferrannini and Cushman, 2012). Many pathophysiological mechanisms trigger this association. In these mechanisms, insulin resistance in the nitric-oxide pathway; the stimulatory effect of hyperinsulinemia on the sympathetic drive, smooth muscle growth, and sodium-fluid retention; and the excitatory effect of hyperglycaemia on the renin–angiotensin–aldosterone system seems to be plausible (Ferrannini *et al.,* 2012).

Genetic variants in the gene encoding angiotensinogen, adrenomedullin, apolipoprotein, and α-adducin have been reported to be associated with common conditions such as diabetes, hypertension, dysglycemia, or metabolic syndrome (Ong, Tso, Leung, Cherny, Sham, Lam et al., 2011). Studies conducted of single nucleotide polymorphisms (SNPs), that predict the development of diabetes were found also to predict the development of hypertension (Ong, Leung, Wong, Cherny, Sham, Lam *et al*., 2008). A study at Columbia University on somatic gene conversion and deletion suggested that multitudes of common SNPs are involved (Ross, 2011). Besides the genetic aspect, another very important aspect for the onset of diabetes and hypertension is environmental.

Environmental factors include the period in utero and lifestyle factors such as diet and physical activity. High intake of sodium, alcohol, and unsaturated fat, smoking, lack of physical activity, and mental stress are examples of an unhealthy lifestyle. It is now realized that insulin resistance, which predicts T2DM, also has a role in the development of hypertension (Sowers, 2004). There is substantial overlap between diabetes and hypertension in etiology and disease mechanisms. Obesity, inflammation, oxidative stress, and insulin resistance are thought to be the common pathways (Cheung and Li, 2012). A study conducted in Ghana in 2006 concluded that hypertension is of public health significance in Ga District of Ghana (Addo, Amoah and Koram, 2006). The high rate of hypertension was associated with low levels of awareness, drug treatment, and blood pressure control (Addo *et a*l., 2006). Overweight and obesity are modifiable risk factors for both hypertension and T2DM that can be addressed through lifestyle interventions. A good body mass index (BMI) is effective in improving T2DM and hypertension and is an important aim of the routine treatment plan. However successful long-term treatment of T2DM is to achieve and maintain a healthy body mass (Jardim et al., 2018). Additionally, integrating hypertension care into primary care in health facilities may prove beneficial (Addo *et al.,* 2006). Indeed, hypertension and diabetes substantially share common pathways such as obesity, inflammation, oxidative stress, mental stress insulin resistance and physical activity.

Hypertension coexists in majority of patients with T2DM and contributes significantly to the increased incidence of both microvascular and macro vascular diseases in these patients (Cheung, 2010). Hypertension and T2DM seem to be two aspects of common pathophysiological pathways, especially in people who suffer from metabolic syndrome. It is estimated that almost two thirds of the population with T2DM is also affected by hypertension (Sowers, 2013). Co-existence of the micro and macrovascular risk factors leads to a four-fold increased risk for cardiovascular disease (CVD) (Hu, Jousilahti and Tuomilehto, 2007). The magnitude of simultaneous prevalence of T2DM and hypertension depends on age, Body mass index and ethnicity. In patients with T2DM, hypertension usually presents early and in combination with other cardiovascular risk factors (De Ferranti, De Boer, Fonseca, Fox, Golden, Lavie. 2014). Aerobic exercises are advised for health promotion and prophylaxis for many diseases. They refer to all exercises that involve major muscle groups and improve oxygen consumption by the body. Many methods of aerobic exercise are available like walking, jogging, running and cycling.

A meta-analytical study confirmed that aerobic exercise resulted in clinically significant reduction in blood pressure (Cornelissen and Smart, 2013). Aerobic exercise such as walking not only improves fitness but also improves overall quality of life and decreases all-cause mortality (Woll, Jekauc, Niermann and Reiner, 2013). Molmen-Hansen, Stolen, Tjonna, Aamot, Ekeberg, Tyldum (2012) also reported that the reducing effects of aerobic exercise on SBP and DBP are intensity-dependent (Molmen-Hansen, Stolen, Tjonna, Aamot, Ekeberg, Tyldum et al., 2012).

2.5 Effects of Physical Activity on Type 2 Diabetes and Hypertension

Physical activity includes all movement that increases energy use, whereas exercise is planned, structured physical activity (Colberg *et al*., 2016). Being physically active is one of the most important actions individuals of all ages do to improve their health. In the United States, an estimated $117 billion in annual health care costs and about 10% of premature mortality are associated with inadequate physical activity (not meeting the existing aerobic physical activity guideline) (Carlson, Adams, Yang and Fulton, 2018). The evidence reviewed by the Physical Activity Guidelines Advisory Committee (Committee, 2008) for the newly released Physical Activity Guidelines for Americans, 2nd edition (Piercy et al., 2018) (PAG) discusses that physical activity fosters normal growth and development and can make people feel better, function better, sleep better, and reduce the risk of many chronic diseases. Some health benefits begin immediately after exercising, and even short episodes or small amounts of physical activity are beneficial (Lotsu *et al*., 2021; Osei-Yeboah *et al*., 2019; Darkwa, 2011). In addition, research shows that virtually everyone benefits from physical activity regardless of gender, races and ethnicities. Physical activity is important for both young and old, for women who are pregnant or postpartum as well as people living with a chronic condition or a disability, including people who want to reduce their risk of disease (Piercy *et al*., 2018). The evidence about the health benefits of regular physical activity is well established and research continues to provide insights into what works to increase physical activity, at both the individual and the community level (Piercy *et al*., 2018). The adoption and maintenance of physical activity are critical for blood glucose management and overall health in individuals with diabetes. Exercises improve blood glucose control in type 2 diabetes, it reduces cardiovascular risk factors such as smoking, physical inactivity, obesity, high blood pressures, high LDL or low HDL cholesterol levels which contributes to weight loss, and improves well-being (Colberg *et al*., 2016; Lin, Zhang, Guo, Roberts, McKenzie, Wu *et al*., 2015).

Including regular exercises in the management of chronic diseases of lifestyle is known to prevent the development of hypertension among patients with T2DM (De Sousa, Fukui, Krustrup, Pereira, Silva, Rodrigues et al., 2014; Association, 2016). Physical activity and exercise recommendations, therefore, aims to meet the specific needs of each individual. During past years, evidence supporting the vital role of physical activity in the prevention and treatment of diabetes has been accumulating (Hayes and Kriska, 2008). Physical activity is recognized to produce multiple general and diabetes-specific health benefits. Regular physical activity leads to a number of beneficial physiological changes that favorably affect muscle and liver insulin sensitivity, muscle glucose uptake and utilization, and overall glycemic control (Toledo, Menshikova, Ritov, Azuma, Radikova, DeLany et al., 2007; Sigal, Kenny, Wasserman, Castaneda-Sceppa and White, 2006; Goodpaster and Brown, 2005). Aerobic exercise facilitates muscle glucose uptake and thus lowers blood glucose levels (Shahgholian, KarimiFard and Shahidi, 2015).

However, the benefits of a physically active lifestyle extend beyond improvements in insulin action and glycemic control. Consistently performed activity can improve lipid profile, decrease body weight and percentage of body fat, lower blood pressure, and positively affect thromboembolic state and thus reduce overall cardiovascular disease risk (Haskell, Lee, Pate, Powell, Blair, Franklin *et al*., 2007; Colberg *et al*., 2016). This reduction in cardiovascular disease risk is of primary importance for individuals with diabetes who are twice as likely to experience serious cardiovascular disease events and are two to four times as likely to die from complications of cardiovascular events compared to the general population (Buse, Ginsberg, Bakris, Clark, Costa, Eckel. 2007; Skerrett and Manson, 2002). Emphasis on regular and consistent activity that includes aerobic exercise supplemented with resistance exercise as part of a healthy lifestyle is important (Sigal et al., 2006; Boulé, Haddad, Kenny, Wells and Sigal, 2001). A study was conducted to review the physical activity in diabetes and summarize the exercise recommendations (Hayes et al., 2008). It was concluded that most types of physical activity, including leisure time activities; recreational games; and high-performance, competitive sports are appropriate for individuals with diabetes (Mellitus *et al*., 2007). However, exercise initiation should be preceded with appropriate medical guidance and pre-exercise screening and must be carefully integrated into the diabetes management plan so that optimal glucose levels can be maintained (Nelson, Rejeski, Blair, Duncan, Judge, King. 2007). Physical exercise is one of the most effective methods to help prevent T2DM and to promote cardiovascular health. Majority of patients with T2DM and hypertension who do not engage in physical activity cannot experience improved glycemic control (Fassett, Robertson, Geraghty, Ball, Burton and Coombes, 2009). Regular physical exercise has proved to be effective not only in improving glycemia by lowering insulin resistance and promoting insulin secretion, but also in reducing the risk of cardiovascular disease and obesity in patients with T2DM (Hamasaki, 2016; Yang, Yang, Li, Han and metabolism, 2019). A study conducted in India showed that people who took part in supervised exercises recorded long-term improvements in blood glucose control and insulin sensitivity than people who engage in home exercises that were not supervised (Sapkota, Shrestha, Khatri and Shrestha, 2018). Meta-analyses have shown that aerobic or resistance training is related to statistically significant improvements in glycemic control (Eccleston, Fisher, Cooper, Grégoire, Heathcote, Krane. 2019; Blake, Rifai, Buring and Ridker, 2003).

Physical exercise can be divided into two types of exercise, aerobic and anaerobic exercises which differ based on the intensity, interval and types of muscle fibers incorporated (Prevention and Promotion, 2018; Patel *et al*., 2017). Aerobic exercise involves repeated and continuous movement of large muscle groups. Aerobic training increases mitochondrial density, insulin sensitivity, oxidative enzymes, compliance and reactivity of blood vessels, lung function, immune function, and cardiac output (Garber, Blissmer, Deschenes, Franklin, Lamonte, Lee. 2011). Moderate to high volumes of aerobic activity are associated with substantially lower cardiovascular and overall mortality risks in both type 1 and type 2 diabetes (Sluik, Buijsse, Muckelbauer, Kaaks, Teucher, Anne *et al.,* 2012). In individuals with type 2 diabetes, regular training reduces glycated hemoglobin, triglycerides, blood pressure, and insulin resistance (Balducci, Alessi, Cardelli, Cavallo, Fallucca and Pugliese, 2007). Daily aerobic exercise, or at least not allowing more than 2 days to elapse between exercise sessions, is recommended to enhance insulin action (Colberg et al., 2016). A multicenter cross-sectional survey in China has found that glucose metabolism, fat metabolism, blood pressure, and body mass index (BMI) were significantly improved after regular exercise in patients with T2DM (Yang *et al.,* 2019; Hamasaki, 2016). Similarly, the decline in prevalence of diabetes-related chronic complications such as diabetic nephropathy, retinopathy, peripheral neuropathy, peripheral vascular disease, and diabetic foot were reported in patients who had full compliance to exercise (Yang *et al*., 2019). Adults with type 2 diabetes should ideally perform both aerobic and resistance exercise training for optimal glycemic and health outcomes (Prevention et al., 2018). Walking is an excellent type of aerobic and cardio activity by which insulin and blood pressure could be regulated (Wen *et al*., 2017; Collier, Kanaley, Carhart, Frechette, Tobin, Hall 2008). Devan, Eskurza, Pierce, Walker, Jablonski, Kaplon, (2013) consider that one explanation for this reduction effect was that regular aerobic exercise could prevent the age-associated vascular endothelial dysfunction. An experiment in rats shows that aerobic exercise training can reduce blood pressure via improving vascular stiffness and endothelial function (Roque, Briones, García-Redondo, Galán, Martínez-Revelles, Avendaño et al., 2013).

Timed walking tests are often used in clinical practice and research to assess aspects of physical function. Several types of walking tests have been developed (Harada, Chiu and Stewart, 1999). They are administered by having the patient walk for a specified distance or a specified time (Harada et al., 1999). The 50-foot walk test is conducted by timing how long it takes a patient to walk a distance of 50 feet (McDonald, Henricson, Han, Abresch, Nicorici, Elfring. 2010). It is often used by clinicians to measure walking velocity over a fixed distance.' The 2-, 6-, and 12-minute walking tests measure the distance walked within their respective time frames. A systematic review of the validity, reliability and responsiveness of the 6MWT in cardiac rehabilitation found it to be a valuable measure (95% CI 54.57 to 66.30) of cardiovascular exercise capacity in elderly patients with cardiovascular conditions (Bellet, Adams and Morris, 2012). In these patients, the distance walked in 6 minutes has a moderate to high correlation with cardiovascular respiratory capacity as measured by maximum oxygen uptake during a treadmill or bicycle exercise test (Bellet *et al.,* 2012). The 6MWT may be used as a tool for the measurement of functional status of a patient especially in the case of advanced diseases with multiple comorbidities who cannot perform more complex exercise tests, such as patients with T2DM and hypertension (Giannitsi, Bougiakli, Bechlioulis, Kotsia, Michalis and Naka, 2019).

The 6MWT should be performed preferably indoors, on a flat, straight, hard-surfaced corridor usually at least 30 m long. The patient is told to be calm, to have taken his/her medications and to wear comfortable clothing and shoes (Hossain and Chakrabortty, 2014). The supervisor records baseline oxygen saturation, heart rate and brachial arterial blood pressure and the Borg scale rating for dyspnea and fatigue. Once the patient has understood the instructions, he/she is ready to begin the test. The walking course must be marked every three meters (3 m) and it is advisable to place cones in the turnaround (Giannitsi *et al*., 2019). During the test the participants have to walk at a rate suitable to their condition and they are allowed to stop or slow down if they feel like doing so and resume walking as soon as possible (Giannitsi *et al.,* 2019). The advantage of the 6-minute walk over treadmill tests of exercise capacity is that it is better tolerated by elderly patients (Peeters and Mets, 1996). Peeters and Mets found that 22% of elderly patients with congestive heart failure were unable to perform treadmill testing because of the speed of the treadmill and consequent fear of falling, whereas all patients were able to complete the 6-minute walk (Peeters *et al*., 1996). As shown by the studies and guidelines presented previously, aerobic exercise is an important complementary treatment strategy for hypertensive control. It has been showed that aerobic exercise is able to reduce SBP and DBP by about seven (7) and five (5) mmHg, respectively (Cornelissen and Smart, 2013). Meanwhile, long-term results (12 and 16 weeks) also show that aerobic exercise plays a beneficial effect on

SBP and DBP level controls (Pitsavos, Chrysohoou, Koutroumbi, Aggeli, Kourlaba, Panagiotakos et al., 2011; Tsai, Chang, Kao, Lu, Chen and Chan, 2002).

2.6 Conclusion

A physically active lifestyle plays a vital role in both managements of hypertension and prevention and management of type 2 diabetes. Benefits of physical activity are numerous and include aiding weight loss and weight maintenance and improving the insulin/glucose profile for people with prediabetes, glycemic control in individuals with type 2 diabetes, and quality of life for all individuals. Of particular importance for people with diabetes is a reduction of high blood pressures (hypertension) and all-cause mortality. Although the independent effect of physical activity in diabetes and hypertension prevention is not known, its role as a key component of a lifestyle intervention that also includes dietary modification and weight loss has been well-documented. Regarding treatment of both diabetes and hypertension, more work is needed to perfect the integration of exercise and other pharmacological therapies in the management of T2DM and HTN. In individuals with type 2 diabetes, regular training reduces glycated hemoglobin, triglycerides, blood pressure, and insulin resistance (Balducci, Alessi, Cardelli, Cavallo, Fallucca and Pugliese, 2007). Daily aerobic exercise, or at least not allowing more than 2 days to elapse between exercise sessions, is recommended to enhance insulin action (Colberg *et al.,* 2016). A multicenter cross-sectional survey in China has found that glucose metabolism, fat metabolism, blood pressure, and body mass index (BMI) were significantly improved after regular exercise in patients with T2DM (Yang et al., 2019; Hamasaki, 2016). The 6MWT may be used as a tool for the measurement of functional status of a patient especially in the case of advanced diseases with multiple comorbidities who cannot perform more complex exercise tests, such as patients with T2DM and hypertension (Giannitsi, Bougiakli, Bechlioulis, Kotsia, Michalis and Naka, 2019).

In summary of this chapter the prevalence of patients diagnosed with T2DM and hypertension is increasing in Ghana, since 2013. There is increased reported death rate from T2DM and hypertension in Ghana and majority of this population reside in Accra. Physical activity is recommended for lifestyle modification in these patients. Although the effects of exercise are well detailed in patients with T2DM and hypertension individually, there is paucity of literature detailing the evidence of aerobic exercises in patients with T2DM, living with hypertension in Ghana.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The previous chapter discussed literature review that covered pathogenesis of T2DM with hypertension and management strategies including aerobic exercises. In this chapter, the general overview of the research design, study setting and population as well as inclusion and exclusion criteria are presented. The sampling method, sample size, instruments used for data collection as well as, measures to enhance quality control and data analysis are described and presented.

3.2 Research Methods

In this study, a quantitative research method was used to determine the effect of aerobic exercises on fasting blood glucose and blood pressure in patients with T2DM living with hypertension in Korle Bu Teaching Hospital (KBTH).

3.2.1 Research Design

According to Akhtar (2016), a study design is a blue print for conducting the study and it maximizes control over factors that could interfere with the desired outcome (Zafar, Sikander, Hamdani, Atif, Akhtar, Nazir et al., 2016). A single arm randomized experimental design was used. The study followed the consort guidelines for randomised controlled trials. In this study participants were their own controls and this was achieved by comparing the baseline results with the post intervention results of the same individual.

3.2.2 Study Setting

The study was conducted at the National Diabetes Management and Research Centre (NDMRC) in Korle- Bu Teaching Hospital (KBTH), Accra and the Department of Physiotherapy of the University of Ghana, KBTH Campus. Patients were recruited from NDMRC and the aerobic exercise protocol was conducted at the Department of Physiotherapy of the University of Ghana all in KBTH.

3.2.3 Study Population

The study involved 60 outpatients diagnosed with T2DM living with hypertension who sought medical management at the National Diabetes Management and Research Centre (NDRMC), Korle Bu Teaching hospital (KBTH).

3.2.4 Statistical Consideration

A statistician was consulted for sample size calculation. A sample size of at least 59 patients was determined to have 90% power to detect a clinically relevant lowering of at least 1.8% in glucose levels after eight (8) weeks of aerobic exercise training. A standard deviation of 4.17% derived from a pilot study of 10 patients with T2DM and hypertension from the National Diabetes Management and Research Centre (NDMRC) used as reference of the study population. Sample size was calculated using a one-sided students t-test and a p-value set at 0.05 level of significance.

3.2.5 Sample Size and Sampling Method

A total sample size of 60 participants were included in this study using simple random sampling of even numbers for all participants who met the inclusion criteria.

3.2.6 Inclusion Criteria

- Male and female patients, who were above the age of 18 years.
- Patients who were diagnosed with type 2 diabetes and hypertension for more than six months.
- Patients who were ambulant.
- Patients who attended the outpatient diabetes clinic at the National Diabetes Management and Research center (NDRMC) in Korle Bu, Accra.

3.2.7 Exclusion Criteria

- Patients with uncontrolled T2DM (glucose levels > 25mmol/L) and hypertension (Systolic >180mmHg, Diastolic > 100mmHg).

- Patients who are newly diagnosed with cancer, unstable angina, myocardial infarction and treated within the previous six (6) months after diagnoses.
- Patients using hormone replacement therapy (HRT) or medications that may affect memory

  (e.g., anticholinergics, sedative hypnotics, narcotics, and anti-parkinsonian agents).
- Patients with neurological problems such as aphasia that result in communication and cognitive impairments.

3.2.8 Data Collection and Organization

3.2.8.1 Data Collection Procedure

RECRUITMENT: this was executed by the researcher at KBTH in Accra, Ghana, on out-patient's diabetes clinic days. The study and its purpose were explained to all outpatients and consent was obtained from those patients who volunteered and met the inclusion criteria to participate in the study (Appendix C). The demographic data such as age and gender as well as medication taken and medical regimen such as time of last meal; acute illness was obtained using a data capturing form (Appendix B).

DATA CAPTURING FORM: a self-designed data capturing form, informed by literature and pre-tested through the pilot study was used. The form consisted of two parts:

Part A: comprised of personal information such as code, folder number, gender, date of birth, age, address, telephone number, next of kin, level of education and mode of transportation.

Part B: comprised of Health Information such as diagnosis and medications and anthropometric measurements, and blood chemistry (Appendix B).

The following tests and outcome measurements were carried out in this study after Part A and B were completed.

Fasting Blood Glucose Level: approximately 5mls (a teaspoon) of blood sample was collected by a Biomedical Scientist at the NDMRC from each participant following an overnight fast. This blood sample was sent off to the central laboratory of KBTH for testing the fasting blood glucose levels. The test was carried out at baseline after completing part A of the data capturing form and at the end of eight weeks' intervention. Baseline test results were submitted to the researcher a week after blood samples was sent to the laboratory, whiles results of blood samples taken at the end of eight weeks were submitted to the researcher after 5 days.

Blood Pressure Level: Blood pressure was measured according to guidelines using an electronic Omron BP machine which displays both SBP, DBP and heart rate. This measurement was taken on each day of exercise, before each participant engaged in a brisk walking exercise and after each bout of exercise. Two measurements were taken by the researcher with a one-minute rest interval and was zeroed after each participant.

ANTHROPOMETRIC MEASUREMENTS:

The anthropometric measurements below were taken by the researcher at baseline and at the end of the intervention (8 weeks).

Body weight:

Each participant's body weight was measured using a calibrated bathroom scale at the NDMRC which was zeroed after each participant. All measurements were rounded to the nearest 0.1 gram.

Height:

A stadiometer was used to measure height in standing against the wall. A long ruler of the stadiometer was in line with the vertex of the head. All measurements were rounded to the nearest 0.1 centimeter.

BMI:

BMI was calculated using the patient's weight and height. The formula is kg/m^2 where kg is the participant's body weight in kilograms and m^2 is their height in meters squared.

Waist to Hip Ratio (WHR):

This is a ratio of the circumference of waist (around the umbilicus) and the hip, around the greater trochanter. These measurements were taken using a tape measure.

EXERCISE CAPACITY

A six-minute walk test (6MWT) developed by the American thoracic society in 2002 was conducted by the researcher at baseline and at the end of eight weeks. Resting Heart rate was recorded from Omron portable BP machine, before engaging in 6MWT.

The following equipment was used during the test:

- a stopwatch
- two small cones to mark the distance measured,
- measurement scale on the floor and a mechanical lap counter was used for the test.

Procedure of the 6MWT

The 6MWT was performed on a walking track that was marked at the physiotherapy department of UG, KBTH. A 30-meter track was marked off in a quiet corridor closer to the emergency department. Intervals of one meter (1m) were also marked clearly for accuracy. In case any of the participants were unable to complete a full 30m distance for one lap, chairs were placed in the middle and at the endpoint of 30m. All participants were given 10-minutes' rest when they arrived at the hospital outpatient department prior starting the 6MWT. During this time, blood pressure and heart rate was measured.

Before the 6MWT started, each participant rated their level of exertion (fatigue) using Rate of Perceived Exertion (RPE) scale. This scale was used to measure how hard the body is working when exercising. The RPE scale runs from zero (0) to -10. Participants were asked by the researcher to rate how hard they were working by assigning numbers to how they feel, from zero to 10. The researcher demonstrated how participants were expected to walk in the marked distance before the test began. Participants were allowed to rest when feeling tired without stopping the clock. At the end of the six minutes' walk or when the participants indicated that they could not go further, the test was stopped and the distance covered measured and recorded. At the end of the test each participant was asked to rate their dyspnea and fatigue levels. Heart rate and blood pressure levels was measured immediately at the end of the activity and after six minutes' rest.

Figure 1, below shows the sequential steps followed by the researcher to assess the participants before engaging in the eight weeks brisk walking intervention.

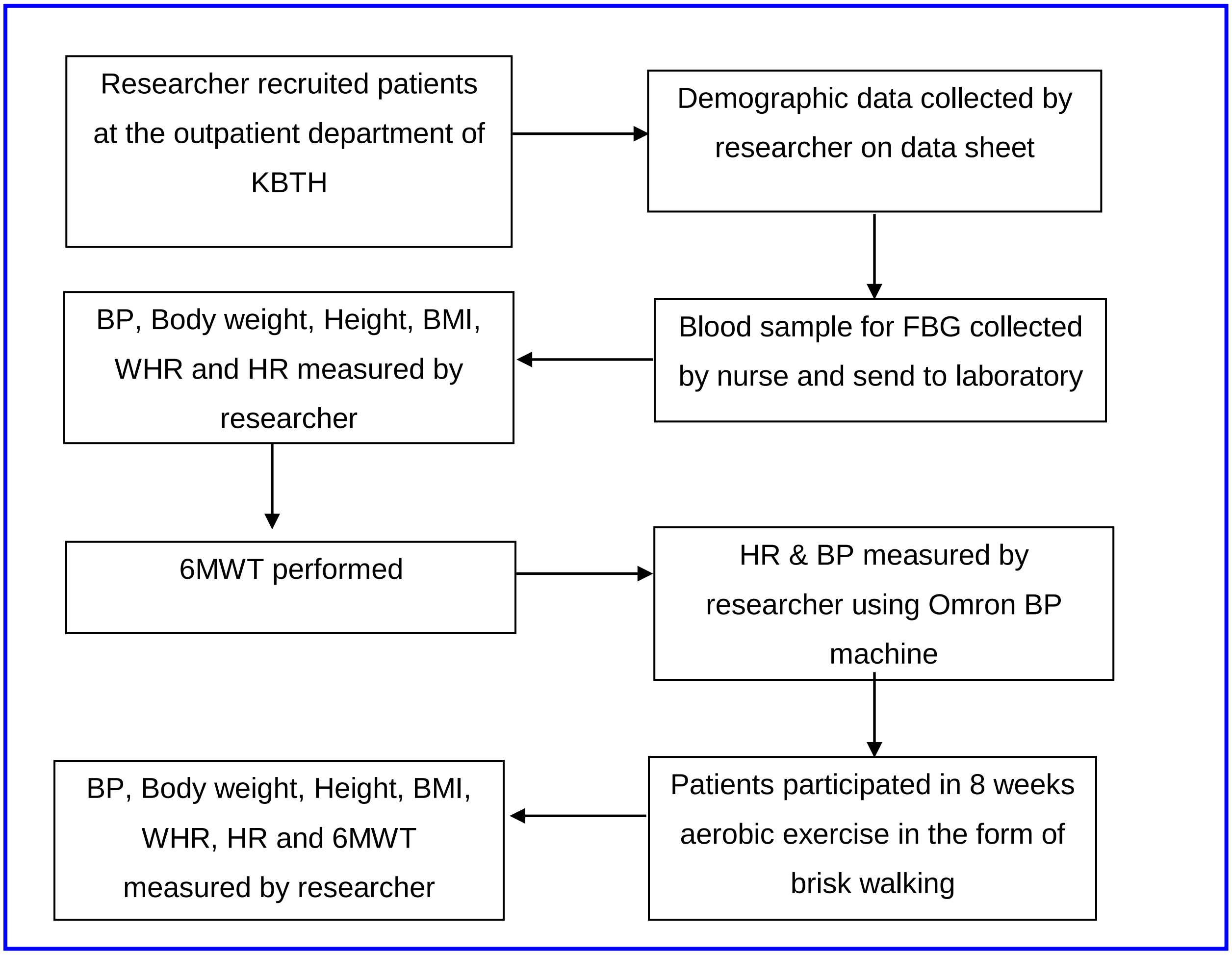

Figure 3.1: Research procedure

3.2.8.2 Intervention

Aerobic Exercise Protocol

On the day of exercises, the heart rate and blood pressure were measured before and after exercise. Each participant was engaged in a supervised brisk walking (aerobic exercise) programme three (3) times per week. The brisk walking programme began a week after the 6MWT-minute walk test was carried out. Brisk walking was carried out in a big and open space without obstacles. Time was used as an outcome measure whilst walking. Participants were encouraged to walk at a minimum time of six minutes and built their walking time steadily until they could walk for 12 minutes in the first week. All participants walked for 12-minutes in the first week to the end of the fourth week, the time was increased to 15-minutes on the fifth week to the end of the sixth week. Time was increased again from 15 to 20-minutes in the seventh week until the last day of the intervention (week 8, day 3). A research assistant, who is a qualified physiotherapist and had undergone a process of training assisted with supervision of participants when performing brisk walking.

After the end of eight (8) weeks all the baseline tests mentioned under procedure were re-evaluated at by the researcher. The study commenced in November 2020 to April 2021. Participants walked in groups of 4-6 participants per hour, with a total of 16 - 20 per day.

3.2.9 Pilot Study

A pilot study was conducted and six participants (10% of the calculated sample size) were recruited from NDRMC. The purpose of the pilot study was to establish whether the data collection sheet included sufficient information about the patient' diagnosis and management as well as to determine if tests and procedures of the study were achievable in the chosen population. Results of the pilot study showed that 20 minutes of aerobic exercises was substantial as most participants struggled to cover the marked distance repeatedly for six minutes. Two of the participants stopped after six minutes which was before the estimated 20 minutes' exercises time after the six-minute walk test. All participants confirmed that this was their first time to engage in exercises, confirming sedentary lifestyle. The exercise time was therefore adapted to start from six minutes and build it until it is 12 minutes in the first week. All other tests and procedures carried out during the pilot study didn't change in the main study.

3.3 Quality Control

All assessment measurements were carried out by the researcher to ensure precision in the readings. The research assistant who helped during walking was given training before the study commenced. All outcome instruments/tools were pre-tested in pilot study before conducting the study. Measurements were repeated twice to ensure accurate results.

3.4 Data Analysis

STATA series 11 statistical package was used to analyse data. Statistics pertaining to changes in fasting blood glucose levels, blood pressure levels, distance walked during the six minutes' walk test and age were summarised using mean and standard deviation at a 95% confidence interval. Categorical data was summarised using frequency, percentage and possible cross tables. A paired t-test was used to compare eight (8) weeks of blood glucose with baseline as well as to compare eight weeks systolic and diastolic blood pressure with averages of week one (1) and week eight (8). Similar analysis was employed for calculating distance walked during the 6MWT and the reported RPE. Testing was done at the 0.05 level of significance. Paired t test was used to test correlation between age, fasting blood glucose and blood pressure, change in fasting blood glucose from baseline (0) to week 8 and correlated with systolic plus diastolic blood pressure week (1_8), which were the averages of the first day week 1 to first day week 8.

3.5 Ethical Considerations

Approval was sought from the Ethics Committee of the University of Pretoria, ethics clearance reference number 779/2019 to conduct the study (Appendix C) at Korle-Bu teaching hospital. An approval and introductory letter were obtained from the Scientific review and ethics committee of KBTH and sent to the National Diabetes Management and Research Centre in the Korle Bu teaching hospital to seek permission to carry out this study (Appendix C). Informed consent of the participants was obtained before recruiting them into the study. Only patients who gave their consent participated in the study. All participant's data was kept confidential and was used only for research purposes. All the ethical aspects prescribed by the ethical committee of the University of Pretoria were followed during the study. Participants were informed that their participation in this study was voluntary and that they could withdraw at any stage from the study without any influence in their management protocol. The results were available to the participants on request after the study.

CHAPTER 4

RESULTS

4.1 Introduction

The previous chapter described the methodology used in this study, in this chapter, the results obtained from analysing the data are first presented descriptively in terms of the participant's profiles. In this study, each participant was a control of their own through a single arm randomised control trial. Participants engaged in an aerobic exercise intervention (brisk walking) three times a week for a period of eight weeks. This is followed by a presentation of the study variable measurements in terms of descriptive analyses and inferential statistics of mean, comparisons and correlations. The results are presented in the following manner:

Demographic characteristics which include gender, age, years of diagnosis, educational status and marriage status

- This is followed by a presentation of the study variable measurements such as fasting blood glucose, blood pressure, BMI, waist hip ratio and distance walked.
- Each outcome measurement results are presented at baseline and after eight weeks post intervention.

4.2 Participants Demographic and Characteristics

The participants comprised of sixty (100%) patients who were diagnosed with both Type 2 Diabetes mellitus (T2DM) and hypertension. Forty-eight (80%) of these participants were diagnosed with T2DM before hypertension whilst twelve (20%) of them were diagnosed with hypertension first before T2DM. Out of the 60 participants, only seven (12%) were diagnosed in less than a year before the study whilst those who had been diagnosed between one and five years before the study were 17 (28%). Participants who had been diagnosed for more than five years before the study were 36 which is 60% of the population. Table 4.1 illustrates the demographic characteristics of all participants.

Table 4. 1 Demographic characteristics of the study participants

Demographics	Frequency (n=60)	Percentage (%)
Gender		
Male	8	13.33
Female	52	86.67
Age (yrs)		
18- 24	1	1.67
25-49	9	15
50 and above	50	83.3
Years of diagnosis		
<1	7	11.67
1-5 years	17	28.33
>5 years	36	60.00
Disease diagnosed first		
Type 2 Diabetes mellitus	48	80.00
Hypertension	12	20.00
Educational status		
Primary	13	21.67
Secondary	12	20.00
Tertiary and above	8	13.33
None	27	45.00
Marital Status		
Married	23	38.33
Single	15	25.00
Divorced/Separated	18	30.00
Widowed	4	6.67

Table 4.1 shows that there were more females than males. Majority of participants were in their middle age, living with diabetes and hypertension for more than five years and did not have formal education.

4.3 Fasting Blood Glucose Levels (FBG) and Blood Pressure

Fasting blood glucose was taken by a professional nurse after an overnight fast at baseline and after the eighth week. The blood pressure (systolic and diastolic pressure) was measured before and after exercise. Paired t-test was used to determine if there was a significant difference between FBG at baseline and after exercising for eight (8) weeks. There was a statistically significant (0.02) difference between baseline and after the end of the eighth week of intervention. The FBG and blood pressure (systolic and diastolic) levels before and after exercise are presented in table 4.2.

Table 4.2 Fasting blood glucose and blood pressure of study participants at baseline and after the intervention

Variable (n=60)	**Baseline Mean (SD)**	**After Intervention Mean (SD)**	**95% CI (Before; After)**	**p-Value (p<0.05)**
FBG	8.79 (3.55)	7.62 (2.73)	(7.87 - 9.71; 6.91 - 8.32)	**0.02***
SBP	141.12(2.91)	120.75 (1.21)	(135.35 - 146.98; 118.33 - 123.17)	**0.00***
DBP	80.78(1.66)	69.38(1.05)	(77.46 - 84.11; 67.28-71.48)	**0.00***

*Indicates statistical difference

There was a significant reduction in the fasting blood glucose and blood pressure at the end of eight weeks of intervention

KEY: FBG= Fasting blood glucose; SBP= Systolic blood pressure; DBP= Diastolic blood pressure

Sd= Standard deviation; CI= Confidence Interval

4.4 Anthropometric Measurements

Anthropometric measurements were taken by the researcher at baseline and at the end of eight weeks of intervention. Table 4.3 below outlines all the measurements at baseline and after eight weeks of the intervention.

Table 4. 3 Anthropometric measurements of study participants at baseline and after the eight (8) weeks of intervention

Variable (n=60)	Baseline Mean (SD)	After Intervention Mean (SD)	95% CI (Before; After)	p-Value ($p<0.05$)
Weight (kg)	81.17 (17.86)	80.73 (16.53)	76.55-85.78; 76.46-85.00	0.2955
Height (m)	1.57 (0.88)	1.57 (0.88)		
BMI	33.17 (8.23)	32.97 (7.66)	31.04 - 35.29; 30.96 - 34.94	0.2611
Hip	45.18 (6.3)	45.83 (6.83)		
Waist	38.3 (5.25)	37.98 (5.17)		
WHR	0.85 (0.07)	0.83 (0.06)	0.83 - 0.87; 0.81 - 0.85	**0.012***

*Indicates statistical significance

Weight and BMI did not change after the end of the eight weeks of aerobic exercise, p=0.29. Waist-hip ratio decreased and this change was statistically significant, p=0.01.

KEY: BMI= Body mass index; WHR= Waist to hip ratio; Sd= Standard deviation; CI= Confidence Interval

4.5 Exercise Capacity Measurements

The following variables were used to measure exercise fitness of all participants at baseline and after the eighth-week aerobic exercise.

- Heart rate
- 6min walk test (6MWT) was used to establish the distance walked
- Borg scale: The Borg scale of perceived exertion was used to rate the perceived level of exertion during the 6MWT

Table 4.4 below, outlines the results of the exercise capacity test at baseline and after the eight-weeks intervention.

Table 4.4 Exercise Capacity measurements of study participants at baseline and after intervention

Variable (n=60)	Baseline Mean (SD)	After Intervention Mean (SD)	95% CI (Before; After)	p-Value (p<0.05)
Heart Rate	74.20 (9.78)	73.37 (9.74)	(71.67 - 76.73; 70.85 - 75.88)	0.73
6 MWT	359.55 (79.85)	421.02 (65.56)	(338.92 - 380.18; 404.08 -437.95)	**0.00***
Borg scale	7.17 (0.87)	5.19 (0.97)	(6.94 - 7.39; 5.72 - 6.22)	**0.00***

*Indicates statistical significance

Participants increased the distance walked compared to baseline with a decreased rate of perceived exertion (RPE). This change was statistically significant, p=0.00.

KEY: 6MWT= Six-minute walk test, Sd= Standard deviation; CI= Confidence Interval

4.6 Association between Age and Changes in Levels of Fasting Blood Glucose and Blood Pressure

The results of the association between age and changes in fasting blood glucose and blood pressure levels are presented in Table 4.5.

Table 4.5 Association between age and changes in levels of fasting blood glucose and blood pressure in patients with type 2 diabetes and hypertension

	Age	FbgB	SbpB	DbpB	FbgA	SbpA	DbpA
Age	1.00						
Fbg B	-0.1926	1.00					
SbpB	0.1419	-0.0432	1.00				
DbpB	0.0241	0.150	0.684	1.00			
FbsA	-0.1597	0.7428	-0.0049	0.076	1.00		
SbpA	-0.0306	-0.0986	0.5181	0.4161	-0.056	1.00	
DbpA	-0.0161	0.1638	0.2635	0.4568	0.158	0.587	1.00

This table shows that there was no correlation between age, fasting blood glucose and blood pressure levels in patients with T2DM living with hypertension after eight weeks of aerobic exercise. The small correlation (shown by negative p-values) coefficients indicate that there is no trend of association.

KEY: FbgB= Fasting blood glucose before exercise, FbgA=Fasting blood glucose at the end of eight weeks of intervention, SbpB = Systolic blood pressure before exercise, SbpA= Systolic blood pressure at the end of eight weeks of exercise, DbpB = Diastolic blood pressure before intervention, DbpA = Diastolic blood pressure at the end of eight weeks of exercise.

The scatter graphs (figures 4.1; 4.2 and 4.3) below also confirm that there was no correlation between age and changes in Fasting blood glucose levels and blood pressure after eight weeks of aerobic exercises. Correlation between FBG 0_8 and age, p= -0.1047. Although the correlative shows a weak relationship (-ve), it can be concluded that there is no correlation because there is no trend displayed in the graphs.

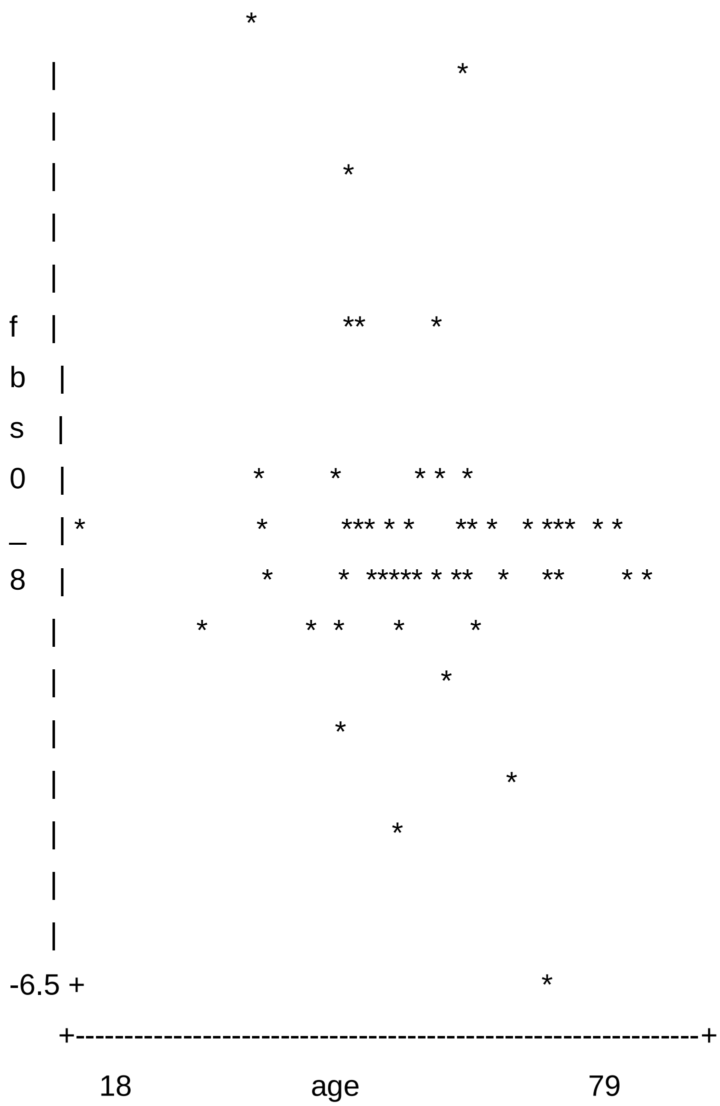

Figure 4.1: Scatter Graph of associations between age and changes in FBG

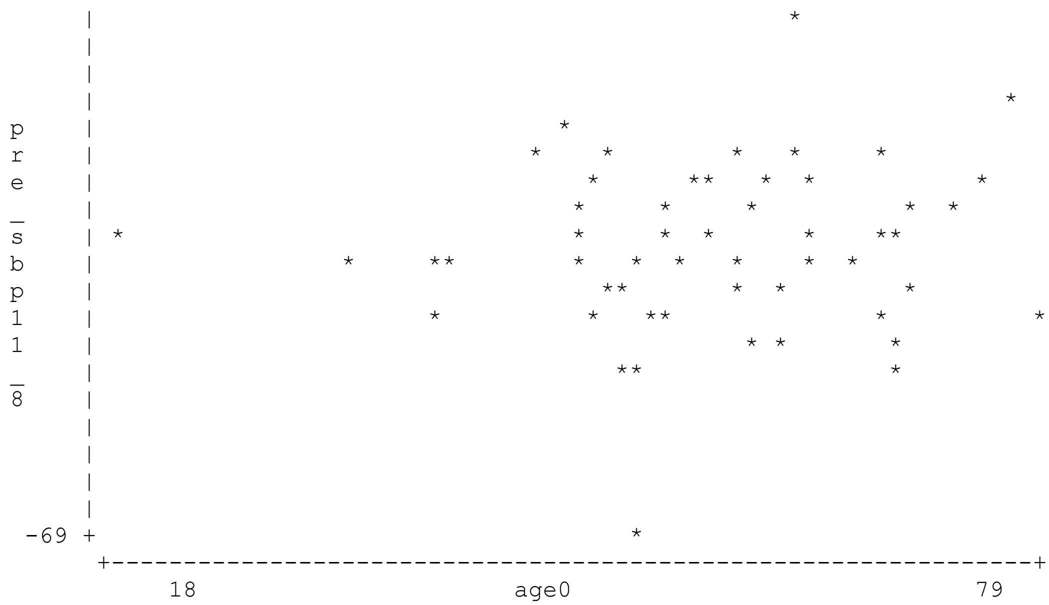

Figure 4.2: Scatter Graph of associations between age and changes in Systolic BP

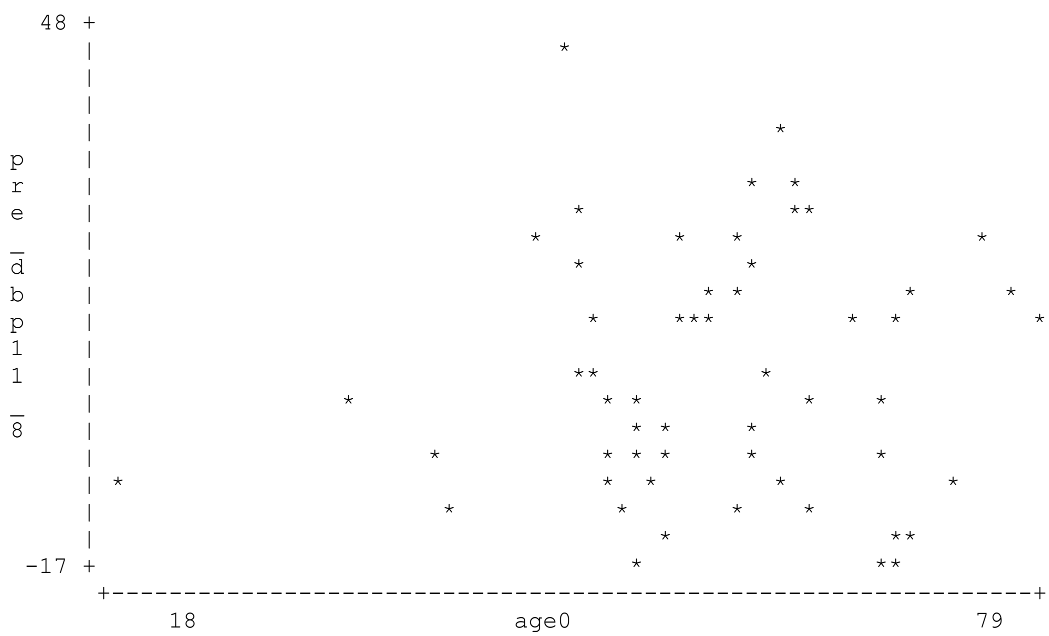

Figure 4.3: Scatter Graph of associations between age and changes in DBP

CHAPTER 5

DISCUSSION

5.1 Introduction

Chapter four presented the results obtained from the study. In this chapter, the main findings of this study are discussed in relation to the aim and objectives and these were compared to similar studies in order to establish the external validity of the present study. The objectives of this study were:

1. To determine the demographic characteristics of patients with type 2 diabetes and hypertension.

2. To determine the fasting blood glucose levels before and after exercise in patients with type 2 diabetes and hypertension.

3. To determine the blood pressure levels before and after exercise in patients with type 2 diabetes and hypertension.

4. To determine the association between age and changes in levels of fasting blood glucose and blood pressure in patients with type 2 diabetes and hypertension.

5.2 Participant's Demographic Characteristics

The results of this study showed higher percentage of females than male participants, and this is supported by the outcomes of other investigators who stated that the statistical representation of prevalence of T2DM and hypertension is more in women than men (Mattioli *et al*., 2019) (Lotsu et *al*., 2021). These results are also in line with a report by Bosu *et al*., 2019, which stated that women in selected African countries including Ghana who were overweight or obese were more likely to develop hypertension in T2DM. A cross-sectional survey study, conducted to evaluate the association of blood pressure with fasting blood glucose levels in Northeast China, demonstrated that fasting glucose decreased in men, but not in women (Lv *et al*., 2018).

Furthermore, majority of participants in this study were in their middle age and had been diagnosed with T2DM before hypertension, they were also diagnosed with comorbidity for more than five years, however few of the participants had been diagnosed with T2DM and hypertension between one to five years. This implies that less people had been diagnosed with

T2DM and hypertension in the past five years. This finding agrees with several studies conducted in other countries including Ghana and confirms that T2DM is diagnosed mostly in adults who are in their middle age (Asamoah-Boaheng *et al*., 2019; Shaikh, 2017; Roglic, 2016; Bello *et a*l., 2011; Mancia, 2005). Findings of this study also showed that T2DM starts before hypertension develops. This conforms to several other studies which have reported similar findings (Bosu *et al*., 2019; Tannor *et al.,* 2019; De Ferranti et al., 2014; Cheung, 2010). A study concluded that baseline blood glucose level is an independent risk factor for new onset hypertension regardless of women and men (Joshipura *et al*., 2018). Most of the participants were not educated, hence could not explore measures (doing regular exercises) to improve their adherence and self-care performance before engaging in this study (Darkwa, 2011). The participants only explored measures that was available (diet and medications) to them at the center. The participants of this study were small scale traders, hence could make time to come for their exercise sessions since the researcher paid their transportation for every visit. Majority of the participants were also married but a greater number had either been divorced/separated or widowed. Additionally, Ghana is a developing country and a large number of the Ghanaian population are uneducated, unemployed with broken homes (Asamoah-Boaheng *et al.,* 2019;).

5.3 Fasting Blood Glucose Levels (FBG) and Blood Pressure

At the end of eight weeks of intervention, the paired t-test with a 95% confidence interval employed in this study, showed that there was a significant difference between FBG at baseline and at the end of eight weeks of doing the supervised aerobic exercises (brisk walking). Reduction in blood glucose levels may be due to the conversion of blood glucose to glycogen to produce energy during aerobic exercise (Patel *et al*., 2017), which facilitates muscle glucose uptake and thus lowers blood glucose levels (Shahgholian *et al*., 2015). The majority of patients with T2DM and hypertension who do not engage in physical activity cannot experience improved glycemic control (Fassett, Robertson, Geraghty, Ball, Burton and Coombes, 2009). Lack of adequate encouragement for the patients, education, inaccessibility of sports sites (Kontos, Miller, Brooks, Jassal, Spanjevic, Devins *et al*., 2007) and problems caused by the pathophysiology of the disease are among the barriers to exercise (Johansen, Kaysen, Young, Hung, da Silva and Chertow, 2003) among these patients. Despite the various obstacles to motivating patients to exercise (Cheema and Singh, 2005), a proper exercise programme will undoubtedly contribute to better control of their blood glucose levels (Lotsu *et al*., 2021). The outcome of this study is consistent with other studies done by Asamoah-Boaheng *et al*., 2019;

and Bello *et al*., 2011 in Accra, Ghana, which also concluded that there was significant reduction in fasting blood glucose levels in patients with T2DM who had undergone aerobic exercise three times a week for eight weeks. Walking is an aerobic exercise and research about the effects of aerobic exercise on blood glucose in patients with diabetes has reported similar results (Maiya, Sunitha and Sarath, 2006). Nayak, Maiya and Hande, (2006) reported that six weeks of aerobic exercise (walking on treadmill) significantly decreased fasting and 2-h postprandial blood glucose levels in patients with diabetes (Nayak, Maiya and Hande, 2005). However, Mikus, Oberlin, Libla, Boyle and Thyfault, 2012 reported that seven (7) days of treadmill exercise did not affect fasting blood glucose in patients with T2DM, contrary to other outcomes. In a study conducted by Aggarwala *et al.* (2016), it was found that the changes in glycaemic control and HbA1c were also not significant ($p>0.05$). It was concluded that duration of four weeks' aerobic exercise on patients with T2DM showed a trend of improvement in glycaemic control and lipid profile did not improve sufficiently as it showed significant changes only in the Very Low Density Lipoproteins (VLDL), whereas triglycerides parameter of lipid profile did not change (Aggarwala, Sharma, Saroochi and Sarkar, 2016).

The findings of this study also showed significant reduction in blood pressure following the eight weeks' intervention. The paired t-test was used to compare baseline systolic blood pressure (SPB) levels directly with the final readings of SBP levels after eight weeks of undergoing aerobic exercises three times weekly. The test showed that there was a significant difference between SBP levels after eight weeks of intervention. Post-exercise hypotension may be the reason for reduction in SBP. This is because during exercise, there is a decrease in the peripheral vascular resistance and thus an overall reduction in blood pressure (Meena, 2016). This is in line with other findings which reported that aerobic exercise is able to reduce both SBP in both male and female patients with hypertension (Wen et al., 2017; Collier et al., 2008). Aerobic exercise is one of the non-pharmacological treatment methods recommended by European and American hypertension guidelines to reduce blood pressure (Weber *et al*., 2014). It is reported that aerobic exercise is able to reduce both systolic (SBP) and diastolic (DBP) in both male and female patients with essential hypertension (Collier et al., 2008). Meanwhile, previous research also reported that exercise training altered the balance between vasodilatation and vasoconstriction-related cytokines, such as nitric oxide (Nyberg, Jensen, Thaning, Hellsten and Mortensen, 2012) prostacyclin, and thromboxane (Hansen, Nyberg, Bangsbo, Saltin and Hellsten, 2011), thereby increasing the diameter of the blood vessels and increasing blood flow.

The paired T-test showed a difference between diastolic blood pressure (DBP) at baseline and DBP at the end of the eight weeks of undergoing aerobic exercises. Baseline and final readings of diastolic blood pressure levels may have changed due to consistent participation in aerobic exercise, which may have led to reduction in peripheral vascular resistance (Nyberg *et al*., 2012). The exercise produced further reduction of blood pressure especially during diastole. These results indicate that aerobic exercise may be a potent non-pharmacological tool/ adjunct for the treatment of hypertension in patients with T2DM, and this is in line with findings of a study conducted by He et al., 2018 As many researches and guidelines presented previously, aerobic exercise is an important complementary treatment strategy for hypertensive control (Pitsavos *et al*., 2011; Tsai *et al*., 2002). As reported by previous studies and the outcome of this study, it could be acknowledged that aerobic exercise, especially brisk walking plays a critical role in the reduction of SBP and DBP in patients with T2DM living with hypertension (Molmen-Hansen et al., 2012). The reduction effect was that regular aerobic exercise could prevent the age-associated vascular endothelial function (Devan, Eskurza, Pierce, Walker, Jablonski, Kaplon et al., 2013). Also, aerobic exercise training can reduce blood pressure via improving vascular stiffness and endothelial function (Roque *et al.*, 2013).

5.4 Anthropometric Measurements

The results of this study showed that there was no statistically significant difference in body weight, even though there was a small reduction at the end of eight weeks of intervention compared to baseline. BMI at the end of eight weeks of brisk walking (aerobic exercise) also showed a small reduction compared to baseline but the calculated p-value was greater than 0.05, hence, there was no statistical significance. Waist to hip ratio, however showed a decrease at the end of intervention compared to baseline, and the difference was statistically significant (p=0.01) This implies that the eight weeks of consistent brisk walking caused reduction of fat around the waist of the participants, even though body weight and BMI were not statistically significant. These results are similar to a study which suggested that healthcare providers can introduce rehabilitation programs such as brisk walking to empower patients to alleviate disease complications and reduce individual and social costs of chronic and cardiovascular diseases (Sahabazi Deh Sokhteh, Pishkar, Rafizadeh and Yaghoubinia. 2021). This finding is also in conformity with a study which concluded that visceral fat reduction was significantly related to weight reduction during aerobic exercise intervention (Ohkawara, Tanaka, Miyachi, Ishikawa-Takata and Tabata, 2007) . Although a significant visceral fat reduction may occur without significant weight loss, however aerobic exercise, such as brisk walking, light jogging or stationary ergometer usage, is required for visceral fat reduction, and there is a dose–response relationship between aerobic exercise and visceral fat reduction in obese persons with metabolic-related disorders such as T2DM and hypertension (Sahabazi Deh Sokhteh et al., 2021; Ohkawara, Tanaka, Miyachi, Ishikawa-Takata and Tabata. 2007). According to Tuomilehto, Lindström, Eriksson, Valle, Hämäläinen, Ilanne-Parikka *et al.,* 2001, aerobic exercise for more than four (4) hours on a weekly basis could reduce the FBS in patients with T2DM without weight loss. Church, 2011 reported that relatively low weight loss can reduce the risk of T2DM. Teixeira-Lemos, Nunes, Teixeira and Reis, 2011 reviewed the effect of regular exercise and concluded that total, visceral and subcutaneous fat decrease occurs following the regular exercise and improved diabetes via glycaemia control and increase of free fatty acids oxidation without weight loss. However, according to Oberbach, Tönjes, Klöting, Fasshauer, Kratzsch, Busse *et al*., 2006 the decrease in BMI may be seen by the combination of endurance exercise and aerobic training. Some studies have reported that in addition prescription of to change the lifestyle of patients with T2DM and hypertension, exercise has positive effects on weight loss, waist circumference, fasting blood glucose and blood pressure (Church, 2011; Praet and van Loon, 2009; Weyer, Funahashi, Tanaka, Hotta, Matsuzawa, Pratley *et al*., 2001). Aerobic exercise improves human body fat metabolic enzyme activity, accelerates fat decomposition and utilization, and effectively inhibits fat synthesis. Therefore, a suitable aerobic exercise intervention gradually eliminates fat accumulation in the body and improves glucolipid metabolism and insulin resistance.

5.5 Exercise Capacity Measurements

Heart rate results showed no statistical significance at the end of eight weeks of intervention, $p>0.05$. The distance walked using a Six minutes' walk test 6 MWT and Borg scale were statistically significant, with p value of 0.000 and 0.000 respectively. This implies that participants improved in their aerobic capacity and endurance to walk better than they started, hence improved the ability of patients in the 6MWT and enhanced their functional exercise capacity. The 6MWT is used as cost-effective method to measure exercise capacity. It has been proven to be useful as a prognostic indicator in the treatment of hypertension among patients with T2DM. This finding is in line with a study conducted by Hasanpour Dehkordi, Ebrahimi-Dehkordi, Banitalebi-Dehkordi, Salehi Tali, Kheiri and Soleimani Babadi, 2021, which revealed that 6MWT and Borg scale values changed significantly after three months of exercise. This is also in agreement with a study which concluded that an encouraged 6MWT is a high-intensity submaximal exercise protocol that shows an oxygen uptake (VO_2) plateau after the third minute of the test (Casas, Vilaro, Rabinovich, Mayer, Barbera, Rodriguez-Roisin *et al.,* 2005). My study supports that 6MWT indicates maximum sustainable exercise that might be related with its predictive value in patients with chronic conditions (Casas *et al*., 2005). The findings of this study suggest that there is some improvement of endothelial function which may contribute to improvements in blood flow and muscle function, but once the muscle function increases, there is improved walking ability which is sustained to the end of eight weeks of brisk walking.

5.6 Association between Age and Changes in Levels of Fasting Blood Glucose and Blood Pressure

The association between age and change in glucose level showed a negative correlation and thus participants with higher age tend to have smaller change (decrease) in fasting blood glucose level in an unreliable manner, hence the results of this study showed a weak correlation between age and fasting blood glucose levels. Since muscle contraction increases glucose uptake in skeletal muscles, aerobic exercises are encouraged as a non-pharmacological treatment method for patients with T2DM. As individuals age, their muscles are not able to function as much as that of individuals with younger age, hence glucose uptake in the skeletal muscle is reduced with increasing age (Teixeira-Lemos, Nunes and Teixeira. 2011; Praet *et al*., 2009).

The association between age and change in SBP showed a weak negative correlation. This signifies that as participants' age increases, SBP levels tend to decrease in a weak manner. The association between age and change in DBP also showed a negative correlation and thus participants with higher age tend to have smaller change (decrease) in diastolic blood pressure. However, the correlation was weak as there was no trend of consistency showed after eight-week intervention.

Aerobic exercise results in a significant positive effect on systolic blood pressure and diastolic blood pressure by causing a statistically significant reduction in both, systolic and diastolic blood pressure at the end of the intervention (Brouwer, Wondergem, Otten, Pisters and rehabilitation, 2021). However, some of the older participants did not experience increased effects as much as the younger participants. This may be due to the fact that the older group may have lost some type 2 muscle fibres simply as a result of aging. Moderate aerobic exercises had a significant effect in lowering arterial blood pressure in elderly patients who had T2DM and developed hypertension, but aerobic exercises would have benefited these elderly participants more if they had started exercising at a relatively younger age (Abd Elwahaab *et al.,* 2019). This finding in this study is important because it supports the inclusion of aerobic exercises as an adjunct in the management of patients with T2DM living with hypertension.

CHAPTER 6

CONCLUSION, LINITATIONS AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study was to determine the effect of aerobic exercises on fasting blood glucose and blood pressure in patients with type 2 diabetes living with hypertension. Based on the outcome of this study it concluded that an eight-week aerobic exercise intervention resulted in statistically significant: -

- Reduction in fasting blood glucose levels of patients diagnosed with T2DM living with hypertension at the end of eight-week intervention compared to baseline.
- Reduction in both systolic and diastolic blood pressure in patients with T2DM living with hypertension at the end of eight-week intervention compared to baseline.
- Increased distance walked and reduction in RPE when baseline is compared to eight weeks at the end of intervention.
- Reduction in WHR in patients with T2DM who are living with hypertension at the end of eight- week intervention compared to baseline

Also, older people tend to have smaller decrease in fasting blood glucose and blood pressure after undergoing consistent aerobic exercises for eight weeks but this change is small and cannot be recorded as significance because not all patients confirmed this correlation as demonstrated in (figures 4.1-4.3). This study also showed a small change in body weight when baseline measurements are compared to eight weeks at the end of intervention. Consistent brisk walking causes reduction of fat around the waist of patients with T2DM living with hypertension, even though the change in BMI was not statistically significant.

Findings from this study suggest that consistent brisk walking can be used to improve exercise capacity in patients with T2DM living with hypertension in a clinical setting. Walking is simply, safe and there are no costs associated with it. As brisk walking was done in groups, it also improved the patients' conceit. Utilising this walk test, physical therapists can make more informed recommendations regarding an exercise regimen that can be tailored for each patient with hopes of maximising adherence and improving overall disease outcomes.

6.2 Limitation

- COVID19 pandemic: due to the outbreak and exacerbation of COVID 19 pandemic, the NDRMC of KBTH was closed for a while hence delayed the commencement of data collection. Also because of COVID 19 pandemic, the number of patients visiting the NDRMC daily was reduced, however, those who visited and consented to participate in the study, expressed a lot of anxiety and fear before consenting to participate which made the data collection period to be monotonous and lengthy.
- The statistician did not adjust for age and gender even though there were big differences between age of participants as well as females to males. These might have contributed to the insufficient power of the study to determine group differences.
- There was selection bias during participant's recruitment and this resulted in gender differences in my study. Therefore, I recommend that future studies should utilise robust sampling strategies to address this sampling bias.
- Financial constraints: the study was fully funded by the researcher including the transportation cost of all participants on every visit. This challenge also contributed to intervention carried out for less than three months which is common in most exercise programs for chronic diseases of lifestyle.

6.3 Recommendations

6.3.1: Clinical Relevance

- Aerobic exercise should be added as an adjunct to the management of patients with T2DM living with hypertension.
- Physiotherapists who treat patients in Korle Bu Teaching Hospital can include education programs about non-communicable diseases and exercise programs for patients who have T2DM and living with hypertension.
- Patients attending the National Diabetes Management and Research Center should be educated more on their condition and the need to incorporate exercise in their management
- Physiotherapists could collaborate with NDRMC to treat patients at the NDRMC just like they see other OPD and ward cases at KBTH.

6.3.2: Research

- Further studies should be conducted using a bigger sample size and must include other hospitals in Accra, Ghana so as to extrapolate the results generally.
- Further studies should make use of a control group to be able to compare the various variables

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APPENDICES

Appendix A1: UP ethical clearance certificate

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 03/14/2020.

22 January 2020

Approval Certificate
New Application

Ethics Reference No.: 779/2019
Title: EFFECTS OF AEROBIC EXERCISES ON FASTING BLOOD GLUCOSE AND BLOOD PRESSURE IN PATIENTS WITH TYPE 2 DIABETES LIVING WITH HYPERTENSION IN GHANA

Dear Miss B Opoku

The **New Application** as supported by documents received between 2019-10-21 and 2020-01-21 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 2020-01-21.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year and needs to be renewed annually by 2021-01-22.
- Please remember to use your protocol number (779/2019) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Dr R Sommers
MBChB MMed (Int) MPharmMed PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

Research Ethics Committee
Room 4-60, Level 4, Tswelopele Building
University of Pretoria, Private Bag x323
Gezina 0031, South Africa
Tel +27 (0)12 356 3084
Email: deepeka.behari@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

Appendix A2: KBTH ethics certificate

In case of reply the number
And the date of this
Letter should be quoted
My Ref. No. KBTH/MD/G3/20
Your Ref. No...........................

KBTH
1923
Excellence in Healthcare

KORLE BU TEACHING HOSPITAL
P. O. BOX KB 77,
KORLE BU, ACCRA.

Tel: +233 302 667759/673034-6
Fax: +233 302 667759
Email: info@kbth.gov.gh
pr@kbth.gov.gh
Website: www.kbth.gov.gh

27th July, 2020

BRIDGETTE OPOKU
FACULTY OF HEALTH SCIENCES
SCHOOL OF HEALTH CARE SCIENCES
DEPARTMENT OF PHYSIOTHERAPY
SOUTH AFRICA

INSTITUTIONAL APPROVAL: KORLE BU TEACHING HOSPITAL-SCIENTIFIC AND TECHNICAL COMMITTEE/INSTITUTIONAL REVIEW BOARD (KBTH-STC/IRB/00015/2020

Following approval of your study entitled: "Effects of Aerobic Exercises on Fasting Blood Glucose and Blood Pressure in Patients with Type 2 Diabetes Living with Hypertension in Ghana" by the Korle Bu Teaching Hospital-Scientific and Technical Committee/Institutional Review Board.

I am pleased to inform you that institutional approval has been granted for the conduct of your study in Korle Bu Teaching Hospital.

Please contact the Head of Department to discuss the commencement date of the study.

Please note that, this institutional approval is rendered invalid if the terms of the Institutional Reviewed Board/Scientific and Technical Committee approval are violated.

Sincere regards,

Dr. Ali Samba
Director of Medical Affairs
For: Chief Executive Officer

Cc: The Chief Executive
Korle Bu

Appendix B: Data capturing form

A. **Personal information**

Code:

Folder number__________________________ Gender_______________________________

D.O.B_________________________________ Age (years)____________________________

Address____

Telephone number________________________ Next of Kin_________________________

Level of Education__________________________ Mode of transport___________________

B. HEALTH INFORMATION

1. Diagnosis:

1.1 What was your first diagnosis?

Type 2 diabetes	Hypertension

1.2 How long have you been diagnosed with type 2 diabetes?

1.3 How long have you been diagnosed with hypertension?

1. Less than a year	2. 1-5 years	3. More than 5 years

1.4 Medication____

2. ANTHROPOMETRIC MEASUREMENTS

Weight (/Kg) ______________________ Height (m)_________________________________

Waist circumference (cm)_______________ Hip circumference (cm)__________________

WHR ____________________ BMI (Kg/m^2 _____________________________________

Resting Pulse__________________________ Pulse after exercise_________________

Distance walked (6MWT)/ (how many minutes walked)
____

Reasons for not completing 6min____

3. BLOOD CHEMISTRY

3.1 Fasting blood glucose: _________before____________________ after
____

3.3 Blood pressure measurements (mmHg)__________2_________ 3_____________

APPENDIX C: PARTICIPANT'S INFORMATION AND INFORMED CONSENT

Title of the Study: Effects of Aerobic Exercises on Fasting Blood Glucose and Blood Pressure of Patients with Type 2 Diabetes living with Hypertension

Investigator: Bridgette Opoku

Date and time of first informed consent interaction:

Day	Month	Year	Time
5th	October	2020	6am

Dear prospective participant

1. **Introduction**

You are invited to volunteer for a research study. I am undertaking this research in fulfilment of the requirements for a Master's degree in Physiotherapy at the University of Pretoria, South Africa. Contained in this document is the information that will help you to understand what the study entails. It is important that you understand all what is involved before you agree to take part in this study. You are free to ask question on any point that is not fully explained in this document. Endeavour not to agree to take part unless you are completely happy about all the procedures involved.

2. The nature and purpose of this study

The aim of this study is to determine the effects of aerobic exercises on fasting blood glucose and blood pressure in patients with type 2 diabetes living with hypertension in Ghana. This may help healthcare professionals to include aerobic exercises in their treatment protocols and not only rely on pharmacological drugs, since diabetes and hypertension will eventually affect the muscles, nerves and tissues of the patients. It will also improve the general wellbeing of patients living with T2DM and hypertension. Aerobic exercises are known to improve blood glucose levels and hypertension; hence this study may help reduce morbidity and mortality rates.

3. Explanation of procedures and what will be expected from participant

This study will be conducted over a period of 8 weeks (two months) and its projected date of completion is December, 2020. If you agree to take part in this study, you will undergo some examinations during which:

(i) You will be asked questions about your general health and treatment that you are receiving at the hospital.

(ii) Your body weight, height, heart rate and blood pressure will be taken to check your cardiovascular health

(iii) Afterwards you will be asked to fill some data capturing form comprising of personal information such as code, folder number, gender, date of birth, age, address, telephone number, next of kin, level of education and mode of transportation while and Part B comprising of Health Information such as diagnosis and medications and anthropometric measurements, and blood chemistry.

(iv) Blood sample for your routine blood tests will also be collected by a professional nurse and analysed by a lab scientist. The researcher will instruct and direct you about the 6MWT and aerobic exercise

You will be guided throughout the process by the researcher and assistant and you may ask question as you deem appropriate. This process will take a maximum of 60 minutes but you may take break if you think you need to do so.

4. Possible risks and discomforts involved

There are no risks associated with the measurements. You may feel tired during the6 MWT and the aerobic exercise but a little rest will suffice. Your heart may beat faster whiles walking but you have seats at various point to rest when you cannot continue. You may feel discomfort when drawing blood but it goes away afterwards.

5. Possible benefits of this study

Knowledge about the effects of aerobic exercises as an adjunct in the reduction of fasting blood glucose and blood pressure levels of patients living with T2DM and hypertension may assist physiotherapists in developing and prescribing the correct aerobic exercise protocols for patients with T2DM and hypertension.

6. Compensation

You will be paid transportation in out to take part in the study. There are no costs involved for you to be part of the study.

7. Your rights as a research participant

Your participation in this study is entirely voluntary and you can refuse to participate or stop participating at any time without stating any reasons. Your withdrawal will not affect your access to medical care. You may contact the principal investigator at any time in order to clarify any issue pertaining to this research.

8. Ethics approval

This protocol will be submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 356 3084/012 356 3085 and written approval is yet to be granted by that committee. The study has been structured in accordance with the Declaration of Helsinki, which deals with the recommendations guiding researchers in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to peruse it.

9. Information

If I have any questions concerning this study, you should contact:

Bridgette Opoku; Tel: +233245687892; E-mail: bbridgeop@gmail.com

10. Confidentiality

All information obtained during the course of this study will be treated with utmost confidentiality. Each participant will be provided with codes as identification. This will ensure confidentiality of information collected from you. Your identity as a participant will not be disclosed to unauthorized people, only the research will be able to identify you as a participant. Results will be published or presented in such a fashion that patients remain unidentifiable. The hard copies of all your records will be kept in a locked facility at the Physiotherapy department of the University of Pretoria.

11. Consent to participate in this study

- I confirm that the person requesting my consent to take part in this study has told me about the nature and process, any risks or discomforts, and the benefits of the study.

- I have also received, read and understood the above written information about the study.
- I have had adequate time to ask questions and I have no objections to participate in this study.
- I am aware that the information obtained in the study, including personal details, will be anonymously processed and presented in the reporting of results.
- I understand that I will not be penalised in any way should I wish to discontinue with the study and that withdrawal will not affect my further treatments.
- I am participating willingly.
- I have received a signed copy of this informed consent agreement.

WRITTEN INFORMED CONSENT

________________________________ ____________________

Participant's name (Please print) Date

________________________________ ____________________

Participant's signature Date

________________________________ ____________________

Researcher's name (Please print) Date

________________________________ ____________________

Researcher's signature Date

VERBAL INFORMED CONSENT *(Only applicable if respondent cannot write)*

I, the undersigned, ______________________________have read and have explained fully to the participant, named _______________________________ and his/her relatives, the informed consent document, which describes the nature and purpose of the study in which I have asked him/her to participate. The explanation I have given has mentioned both the possible risks and benefits of the study. The participant indicated that he/she understands that he/she will be free to withdraw from the study at any time for any reason and without jeopardizing his/her standard care.

I hereby certify that the participant has agreed to participate in this study.

________________________________ ____________________

Participant's name (Please print) Date

________________________________ ____________________

Participant's signature Date

________________________________ ____________________

Researcher's name (Please print) Date

________________________________ ____________________

Researcher's signature Date

________________________________ ____________________

Witness's name (Please print) Date

_________________________________ _____________________

Witness's signature Date