RELATIONSHIP BETWEEN LOWER EXTREMITY STRENGTH, QUALITY OF LIFE AND MOVEMENT PERFORMANCE CAPACITY IN PATIENTS WITH TYPE 2 DIABETES MELLITUS .

BY

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CERTIFICATION

This dissertation by Edawa-Dudu, Ofeoritse Salome is accepted in its present form as satisfying the dissertation requirement of the degree of Bachelor of Physiotherapy of the School of Basic Medical Sciences, College of Medical Sciences of the University of Benin.

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DEDICATION

This study is dedicated to my sister, Mofe. Thank you so much for your love, support and encouragement.

ABSTRACT

Background/Purpose of the study: Lower extremity strength, quality of life and movement performance capacity are some of the clinical features that can be affected in patients with type 2 diabetes mellitus. The purpose of this study was to investigate the relationship between these clinical features and their significance.

Methods: A total of 167 male and female type 2 diabetes mellitus (DM) patients with age 65 years and above participated in this correlational study. Quality of life, movement performance capacity and lower extremity muscle strength (LEMS) of the participants were measured using WHOQOL-BREF questionnaire, Short Physical Performance Battery and an improvised leg dynamometer respectively. Obtained data were summarized with descriptive statistics and inferential statistics of Pearson's correlation coefficient test was used to analyze the relationship between LEMS and movement performance capacity, Spearman's rank correlation coefficient test was used to analyze the relationship between LEMS and quality of life. All inferential analyses were performed at 0.05 alpha levels.

Results: 90 (53.9%) of the respondents were female, 119 (71.3%) of the respondents were married. Right and left LEMS had significant positive correlation with QOL and movement performance capacity ($\rho<0.001$). There were positive significant relationships between movement performance capacity and the domains of WHOQOL; physical health ($\rho<0.001$), psychological ($\rho<0.001$), social relationships ($\rho = 0.009$) and environment ($\rho<0.001$).

Conclusion: There was a significant relationship between lower extremity strength, quality of life and movement performance in patients with type 2 DM.

Keywords: Type 2 diabetes mellitus, Lower extremity strength, Quality of life, movement performance capacity.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Diabetes mellitus (DM) is a chronic metabolic disorder that is associated with a reduction in the production of insulin or in some cases, the insulin is available but the body cannot use it properly which results in sustained hyperglycemia and disruptions to majority of the body metabolic functions (Mukhtar et al., 2020).

According to American Diabetes Association (ADA), diabetes can be classified into four categories: Type 1 diabetes, which occurs due to destruction of beta cell and eventually results in reduced insulin production; Type 2 diabetes, which is characterized by an insulin resistance; Gestational Diabetes Mellitus (GDM) which is usually diagnosed during the second or third trimester of pregnancy; and Special types of diabetes which occurs due to other causes such as drug or chemical-induced diabetes, diseases of the exocrine pancreas (American Diabetes Association, 2018).

The American Diabetes Association (ADA) also lists seven major symptoms of DM and these are: frequent urination, extreme hunger, extreme thirst, unusual weight loss, increased fatigue, blurry vision, irritability (Clark et al., 2007).

There is a rapid rise in the prevalence of diabetes mellitus all over the world, this could be due to the increase in obesity and unhealthy lifestyles (Alam et al., 2021).

In the year 2019, it was estimated that 463 million people have diabetes and that by the year 2030 there will be an increase in this number to 578 million people who will have diabetes (Saeedi et al., 2019). Dahiru et al., (2016) reported that in the year 2013, Sub-Saharan Africa was estimated to have 20 million people with diabetes with Nigeria being the leading country having an estimated 3.9 million people with diabetes from ages 20-79 years old.

The most common form of diabetes mellitus is the type 2 diabetes mellitus (T2DM) and it accounts for over 90% of diabetic cases (Galicia-Garcia et al., 2020). The prevalence of type 2 diabetes ranges from 0.7 to 11.6% in Europe, 1.2 to 14.6% in Asia, 2.01 to 17.4% in South America and 0.3 to 17.9% in Africa (Adeghate et al., 2006). T2DM was said to have caused 4.6 million deaths in 2011 and that by the year 2030, there will be 439 million people who have type 2 DM (Olokoba et al., 2012). The incidence and prevalence of T2DM vary according to geographic location, with more than 80% of patients residing in low- to middle-income nations, which adds to the difficulties of providing effective care (Galicia-Garcia et al., 2020).

A major risk factor of T2DM is excess body weight, it has been shown that most individuals with T2DM are either overweight or obese with obesity accounting for 55% of T2DM cases (Alam et al., 2021; Olokoba et al., 2012). The risk factors of T2DM can be divided into modifiable and non-modifiable factors; some of these modifiable factors are obesity, low physical activity, intake of alcoholic beverages, smoking and unhealthy diet while the non-modifiable factors are ethnicity and family history/genetic predisposition (Galicia-Garcia et al., 2020; Alam et al., 2021).

Lower extremity strength is one of the components that can be affected in patients with T2DM as these patients can sometimes present with muscle weakness (Andersen et al., 2004). A major cause of this reduced lower extremity strength is diabetic polyneuropathy (DPN) which T2DM patients tend to develop, DPN is present in approximately 20-40% T2DM patients (Ijzerman et al., 2012). A study by Andersen et al., (2004) reported that patients with T2DM have muscle weakness at their knee and ankle which related to the severity of their neuropathy.

Inactivity and disuse of the muscles likely contribute to the relative weak muscle strength since lack of physical activity is one of the risk factors in the development of T2DM (Ijzerman et al., 2012).

Movement performance capacity can also be affected in patients with T2DM, individuals with T2DM are less active and have more functional impairment than people who do not have the disease, this could be due to vascular and neuropathic complications which affect somatosensory and motor function (Kirkman et al., 2012; Kraiwong et al., 2019). The ability to engage in activities such as walking, climbing stairs, bending, stretching, lifting and carrying objects, is important in daily living and to be able to do this without restriction is referred to as physical functioning (Oke et al., 2013). The individual's quality of life and overall well-being have a strong connection with their functional physical performance (Oke et al., 2013).

Complications from diabetes lead to altered peripheral sensory and motor pathways, increased postural sway, and abnormal gait pattern which increase the risk of fall among this population (Fulk et al., 2010).

Weakness of the lower limb muscles also affects the movement performance capacity of T2DM patients, they experience difficulty moving, maintaining balance and are prone to falls (Kraiwong et al., 2019). For example, weak ankle dorsiflexors will cause heel strike which is an essential component of gait cycle to become difficult, this will hinder proper movement of the individual (Kraiwong et al., 2019).

In a study conducted by Awotidebe et al., (2016), it was reported that patients with T2DM had slower gait speed and shorter step length. Geriatricians and physiotherapist therefore recommend the assessment of gait speed among diabetic older adults as it can serve as an essential clinical sign (Oke et al., 2009).

In addition, it is important that the Health Related Quality of Life (HR-QOL) of T2DM patients be assessed, this refers to the patient's perspective of their physical, emotional, mental and social status (Al-Shehri et al., 2008; Jing et al., 2018; Oyewole et al., 2023). The Quality of life (QOL) of the patient may present in different forms ranging from difficulty performing physical functions due to complications of diabetes such as reduced muscle strength mentioned earlier to experiencing exhaustion and depression due to high blood sugar levels (Al-Shehri et al., 2008). Salawu et al., (2018) reported that up to 50% of T2DM patients will experience DPN at some point in their lives, which will significantly lower their quality of life. Therfore the aim of diabetes care is to prevent a decline in the QOL of the patient (Saleh et al., 2015).

In a study conducted by Ijzerman et al., (2011), it was reported that patients with type 2 DM (T2DM) have reduced muscle strength, impaired mobility and reduced health related quality of life (HR-QOL), this makes it difficult for the patient to independently carry out basic activities of daily living.

1.2 Statement of the problem

Increase in the prevalence of type 2 DM and its complications especially among the elderly is of growing concern. While some studies have reported how T2DM affects muscle strength, mobility and quality of life ((Kraiwong et al., 2019; Ijzerman et al., 2012; Andersen et al., 2004), there is a paucity of publications in Nigeria that directly look at the relationship between lower extremity muscle strength, movement performance capacity and quality of life in T2DM patients. This study therefore aims to fill this gap and provide insight into the significance of these components and why they should be assessed and closely monitored.

Research questions

i. What is the lower extremity muscle strength of patients with type 2 DM?

ii. What is the quality of life of patients with type 2 DM?

iii. What is the movement performance capacity of patients with type 2 DM?

iv. What will be the relationship between lower extremity muscle strength, quality of life, and movement performance capacity in patients with type 2 DM?

1.3 Aim of the study

The aim of this study was to determine the relationship between lower extremity strength, quality of life and movement performance capacity in patients with type 2 DM.

1.3.1 Specific Objectives

The specific objectives of the study are to determine the

i. lower extremities muscle strength of patients with type 2 DM.

ii. quality of life of patients with type 2 DM.

iii. movement performance capacity of patients with type 2 DM.

iv. relationship between the lower extremity strength, quality of life and movement performance capacity of patients with type 2 DM.

1.4.1 Main Hypothesis

i. There would be no significant relationship between the lower extremity strength, quality of life and movement performance capacity of patients with type 2 DM.

1.4.2 Sub-Hypotheses

i. There would be no significant relationship between right lower extremity strength and movement performance capacity of patients with type 2 DM.

ii. There would be no significant relationship between right lower extremity strength and quality of life of patients with type 2 DM.

iii. There would be no significant relationship between left lower extremity strength and movement performance capacity of patients with type 2 DM.

iv.There would be no significant relationship between left lower extremity strength and quality of life of patients with type 2 DM.

v. There would be no significant relationship between movement performance capacity and quality of life of patients with type 2 DM.

vi. There would be no significant association between duration of type 2 DM and movement performance capacity of patients with type 2 DM.

vii. There would be no significant association between severity of symptoms and movement performance capacity of patients with type 2 DM.

viii. There would be no significant association between gender and movement performance capacity of patients with type 2 DM.

ix. There would be no significant association between gender and physical health QOL of patients with type 2 DM.

x. There would be no significant association between gender and psychological QOL of patients with type 2 DM.

xi. There would be no significant relationship between gender and social relationships QOL of patients with type 2 DM.

xii. There would be no significant association between gender and environment QOL of patients with type 2 DM.

xiii. There would be no significant association between duration of type 2 DM and physical health QOL of patients with type 2 DM.

xiv. There would be no significant association between duration of type 2 DM and psychological QOL of patients with type 2 DM.

xv. There would be no significant association between duration of type 2 DM and social relationships QOL of patients with type 2 DM.

xvi. There would be no significant association between duration of type 2 DM and environment QOL of patients with type 2 DM.

xvii. There would be no significant association between severity of symptoms and physical health QOL of patients with type 2 DM.

xviii. There would be no significant association between severity of symptoms and psychological QOL of patients with type 2 DM.

xix. There would be no significant association between severity of symptoms and social relationships QOL of patients with type 2 DM.

xx. There would be no significant association between severity of symptoms and environment QOL of patients with type 2 DM.

1.5 Significance of the study

The outcome of this study ;

i. Provided information on the relationship between lower extremity strength, quality of life and movement performance capacity in patients with type 2 DM.

ii. Presented the importance of assessing and improving the lower extremity strength, quality of life and movement performance capacity in patients with type 2 DM.

1.6 Scope of the study

This study is delimited to:

i. Male and female type 2 DM patients in University of Benin Teaching Hospital (UBTH).

ii. Older patients from 65years and above.

1.7 Limitations of the study

i. Reluctance of some of the patients to participate.

ii. Difficulty in understanding some of the instructions by the patients.

1.8 Definition of Terms

i. Lower extremity strength: the lower extremity refers to the part of the body from the hip to the toes, the lower extremity strength is the physical state of the muscles present in this part of the body.

ii. Quality of life: assessment of well-being of an individual's life comprising of the physical, psychological, environmental and social aspects.

iii. Movement performance capacity: ability to carry out a required movement.

iv. Diabetes Mellitus: is a chronic metabolic disorder that is characterized by decreased production of insulin.

1.9 List of abbreviations

DM	Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
HR-QOL	Health Related Quality of Life
ADA	American Diabetes Association

LES	Lower Extremity Strength
QOL	Quality of Life

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Diabetes Mellitus

Diabetes Mellitus (DM) is a metabolic disorder that results from a deficiency in insulin production, insulin action or both (Kharroubi and Darwish, 2015). The body require insulin which is produced by the pancreas to transport glucose from the blood to the cells where they are used, but this is a problem for a diabetic patient as either the insulin produced is not sufficient or the insulin cannot be used, eventually leading to abnormal levels of glucose in the blood (Mukhtar et al., 2020). The main distinguishing features of diabetes mellitus are hyperglycaemia, polyuria, polyphagia and polydipsia (Alam et al., 2021).

There are three main types of diabetes: Type 1 DM, also known as insulin-dependent diabetes mellitus (IDDM), in which the body is unable to manufacture insulin and the patient must constantly administer insulin intravenously or use an insulin pump, this type is also known as "juvenile diabetes"; the second form is the Type 2 DM also known as non-insulin-dependent diabetes mellitus (NIDDM), it is characterized by insulin resistance in which cells are unable to adequately utilize insulin, whether or not there is an absolute insulin deficit. Previously, this variety was known as "adult-onset diabetes." The third major form is gestational diabetes, which develops when pregnant women without a history of diabetes experience high blood sugar levels which might lead to Type 2 DM after giving birth (Mukhtar et al., 2020).

Type 2 DM is the most common type of DM with its major risk factors being lifestyle and genetics (Olokoba et al., 2012). About 55% of the cases of type 2 DM are found in obese individuals (Olokoba et al., 2012).

2.2 Epidemiology

The worldwide prevalence of DM is estimated to be about 463 million and is expected to rise to 578 million by 2030 (Saeedi et al., 2019). Type 2 DM accounts for 90% of these cases (Saeedi et al. 2019).

Diabetes is thought to be prevalent in Africa at 1% in rural areas, up to 7% in urban sub-Saharan Africa, and 8-13% in more developed regions like South Africa and among people of Indian descent; while the prevalence in Nigeria ranges from 0.65% in rural Mangu (North) to 11% in urban Lagos (South), and according to data from the World Health Organization (WHO), Nigeria has the highest rate of persons with type 1 diabetes in Africa (Mukhtar et al., 2020). Ages 40 to 59 account for the largest percentage of diabetic patients (Galicia-Garcia et al., 2020).

Cardiovascular disease (CVD) is the main cause of morbidity and mortality related to T2DM, with patients having a 15% higher risk of death from all causes compared to those without diabetes (Galicia-Garcia et al., 2020).

2.3 Risk Factors of Diabetes Mellitus

There are several risk factors of DM such as genetics, environment, loss of the very first phase of insulin release, sedentary lifestyle, lack of exercise, smoking, alcohol use, dyslipidemia, reduced beta-cell sensitivity, hyperinsulinemia and improved glucagon activity (Alam et al., 2021). Obstructive sleep apnea and sleep disorders are common risk factors for insulin resistance and glucose sensitivity, which together lead to prediabetes and eventually type 2 DM, these conditions are seen in overweight adult persons and that is why type 2 DM has long been associated with individuals with excess body weight (Alam et al., 2021).

Although ethnicity and family history/genetic predisposition, which are non-modifiable risk factors for T2DM, have a strong genetic basis, epidemiological studies have shown that many cases of T2DM can be prevented by addressing the major modifiable risk factors which are obesity, inactivity, and poor diet (Galicia-Garcia et al., 2020).

2.4 Pathophysiology of Type 2 DM

Type 2 Diabetes Mellitus (T2DM), is brought on by a combination of two main causes: inadequate insulin secretion by pancreatic beta-cells and inadequate insulin response in insulin-sensitive organs (Galicia-Garcia et al., 2020). There are detectable levels of circulating insulin in individuals with type 2 DM compared to that of individuals with type 1 DM (Ozougwu et al., 2013).

Peripheral insulin resistance, poor control of hepatic glucose synthesis, and diminishing beta-cell function, which ultimately results in beta-cell failure, are the pathophysiological features of type 2 diabetes mellitus (Mahler & Adler, 1999).

Beta cell dysfunction- Recent research suggests that the dysfunction of beta-cells in T2DM may result from a more intricate network of interactions between the environment and many molecular pathways involved in cell life (Galicia-Garcia et al., 2020). Hyperglycemia and hyperlipidemia are frequently present in an excessive dietary state such as obesity, encouraging insulin resistance (IR) and chronic inflammation; in these conditions, beta-cells are vulnerable to toxic stresses such as inflammation, inflammatory stress, endoplasmic reticulum (ER) stress, metabolic/oxidative stress, and amyloid stress, which have the potential to ultimately result in the loss of islet integrity thereby impairing ideal cell-to-cell communication within pancreatic islets, causing poor regulation of insulin and glucagon release, and ultimately aggravating hyperglycemia (Galicia-Garcia et al., 2020). A high level of free fatty acids (FFAs) and hyperglycemia cause ER stress by activating the apoptotic unfolded protein response (UPR) pathways which eventually leads to beta-cell dysfunction (Galicia-Garcia et al., 2020). Sustained high glucose levels increase proinsulin biosynthesis and islet amyloid polypeptides (IAAP) in beta-cells, which results in the accumulation of misfolded insulin, IAAP and increase in the production of oxidative protein folding-mediated reactive oxygen species (ROS); also, stress resulting from high levels of saturated free fatty acids (FFAs) can activate the apoptotic unfolded protein response (UPR) pathway by inhibition of the sarco/endoplasmic reticulum Ca2+ ATPase (SERCA), which is responsible for ER Ca2+ mobilization, direct disruption of ER homeostasis or activation of IP3 receptors (Galicia-Garcia et al., 2020).

Insulin resistance: Insulin resistance (IR) state is caused by: (i) insulin antagonists in the blood plasma, which are caused by either counter-regulatory hormones or by non-hormonal bodies that affect insulin receptors or change the effectiveness of insulin signaling; and (ii) the target tissue being incapable of responding to insulin due to defects either in the effector systems or insulin receptors; this second form is the most significant here because this form of insulin resistance is common in all type 2 DM individuals (Pearson et al., 2016). The tissues involved in insulin-mediated glucose uptake, notably muscle and, to a lesser extent, adipose tissue, have been the focus of basic research in the domain of insulin resistance as a core component of the pathogenesis of type 2 diabetes (Matthaei et al., 2000). Another insulin-sensitive organ that play a major role is the liver (Galicia-Garcia et al., 2020).

Skeletal muscle: The most significant extra-pancreatic component in the onset of T2DM is thought to be skeletal muscle IR. The enzymes glycogen synthase and hexokinase, as well as the glucose transporter (GLUT-4), are three potential rate-controlling stages that might be to blame for the decreased rate of insulin-stimulated muscle glycogen synthesis in people with type 2 diabetes (Petersen & Shulman, 2002). After insulin binds to the insulin receptor (INSR) in muscle cells, GLUT4 moves from intracellular sites (early endosomes (EE), endosomal recycling compartment (ERC), and trans-Golgi network (TGN)) to the plasma membrane, allowing glucose uptake and lowering blood glucose levels (Galicia-Garcia et al., 2020).

In a pathological condition, the above does not happen. A hyperglycaemic state would result from mutations that decrease the expression of the insulin receptor or GLUT4, any flaw in either the upstream or downstream signaling pathway, or mutations in any of the primary phosphorylation sites can reduce insulin binding to insulin receptor (INSR) tyrosine kinase activity which in turn reduces the ability of insulin to act on skeletal muscle (Galicia-Garcia et al., 2020).

Environmental factors can also have a big impact on how much glucose is taken up by muscle, in addition to mutations or poor epigenetic regulation (Galicia-Garcia et al., 2020). Exercise improves blood flow to skeletal muscle cells, which improves glucose uptake and in a case of reduced physical activity, the opposite occurs, this is why obesity which is connected to chronic inflammation has a high impact on IR and T2DM (Galicia-Garcia et al., 2020). Research has shown that skeletal muscle inflammation is a result of obesity-related increases in immune cell infiltration and release of proinflammatory chemicals in intermyocellular and perimuscular adipose tissue (Wu & Ballantyne, 2017). As a result, myocyte inflammation, decreased myocyte metabolism, and paracrine actions all help to cause IR (Wu and Ballantyne, 2017).

Adipose Tissue: Insulin affects adipose tissue by i) promoting glucose absorption and triglyceride synthesis and ii) reducing triglyceride hydrolysis and the release of FFA and glycerol into the circulation (Gastaldelli et al., 2017). Elevated plasma FFA levels have been demonstrated to impair muscle insulin signaling, encourage hepatic gluconeogenesis, and impair glucose-stimulated insulin response (Gastaldelli et al., 2017). Adipose tissue insulin resistance (Adipo-IR), which is the impaired suppression of lipolysis in the presence of high insulin levels, has been associated with glucose intolerance (Gastaldelli et al., 2017). Subcutaneous adipose tissue is resistant to the antilipolytic impact of insulin in obese people with and without type 2 diabetes mellitus (T2DM) and because insulin is an adipogenic hormone, it promotes the deposition of subcutaneous fat as well as ectopic fat in the liver, muscle, pancreas, heart, and other tissues by increasing the absorption of circulating fatty acids and enhancing triglyceride synthesis (Gastaldelli et al., 2017).

Even in the presence of high insulin levels, adipose-IR can cause impaired glucose uptake, impaired lipolysis suppression, and increased FFA release into plasma which then builds up in other tissues like the muscle or liver and in the liver, FFA buildup causes poor insulin signaling, which encourages hepatic gluconeogenesis and compromises the insulin response to glucose stimulation, leading to the onset of T2DM (Galicia-Garcia et al., 2020).

Liver: The regulation of the body's overall energy homeostasis is largely controlled by the liver, an organ that is sensitive to insulin, thus, it is expected that insulin resistance in metabolically active hepatocytes will have significant systemic effects (Leclercq et al., 2007). Insufficient insulin-mediated inhibition of hepatocyte glucose synthesis is referred to as hepatic insulin resistance (Leclercq et al., 2007). In conditions of IR, normal levels of circulating insulin are insufficient to elicit the proper insulin response in hepatic cells, therefore, IR reduces glycogen synthesis, fails to control glucose production and promotes lipogenesis (Galicia-Garcia et al., 2020). Fasting hyperglycemia and ongoing stimulation of insulin production by pancreatic beta-cells are largely caused by insulin's inability to suppress hepatic gluconeogenesis and glycogenolysis (Leclercq et al., 2007). Insulin resistance in hepatocytes disrupts glucose metabolism, particularly the control of glucose output into the circulation, and interferes with cell survival and proliferation, whereas compensatory hyperinsulinaemia stimulates hepatic fatty acid synthesis, resulting in steatosis (fatty liver) (Leclercq et al., 2007).

2.5 Diagnosis

Type 2 diabetes is diagnosed when the underlying metabolic abnormalities, which include insulin resistance and decreased beta-cell function, result in an elevation of plasma glucose above 126 mg/dl (7 mmol/liter) in the fasting state and/or above 200 mg/dl (11.1 mmol/liter) 120 minutes after a 75 g glucose load (Matthaei 2000). The International Expert Committee(IEC) in July 2019, identified the range of 6.0% and <6.5% of glycated hemoglobin levels (HbA1c) to signify high risk of developing DM (International Expert Committee, 2009).

2.6 Management:

Management of DM can be through modification of lifestyle and diet (Olokoba et al., 2012). General management include education of patients, use of medications such as insulin, nutrition therapy and physical activity (Nyenwe et al., 2013).

Medical management

A combination of lifestyle modifications and monotherapy, preferably with metformin, is advised as a first line of treatment, according to the American Association of Clinical Endocrinologists/American College of Endocrinology and the American Diabetes Association (Thrasher, 2017). Within 3 months of beginning initial therapy, if the HbA1c (glycated hemoglobin) goal has not been reached, treatment is intensified by adding a second agent, if the HbA1c target is not reached, glycemic control is reevaluated in about 3 months, and triple therapy considered; combination injectable therapy with basal insulin may be attempted to achieve glycemic control if the HbA1c target is still not met (Thrasher, 2017).

Role of physiotherapy in management of T2DM

Physiotherapy interventions such as exercise therapy have been reported to be beneficial in the management of T2DM, there is usually a drop in glucose parameters following exercise, insulin sensitivity rises, which causes a surge in glucose uptake by contracting muscles, enhances metabolism of lipids and glucose, muscular and cardio respiratory fitness, decrease in obesity and fat level (Kaur and Singh, 2022). Also, since sedentary lifestyle is a significant but modifiable risk factor for T2DM, moderate exercise is extremely beneficial for diabetic people (Nyenwe et al., 2013). Improvements in insulin sensitivity and glucose disposal in skeletal muscle, endothelial cell production of nitric oxide synthase, reduction in obesity, and improvements in body fitness are just a few of the ways in which exercise benefits people with diabetes (Nyenwe et al., 2013).

Another physiotherapy intervention that has been found to be beneficial is the whole body vibration which operates on the premise that more motor units will be engaged in response to vibration stimulus, which will improve muscle response and, in turn, promote insulin sensitivity and glycemic management (Cardinale and Bosco, 2003).

Complications that arise from T2DM such as diabetic polyneuropathy, diabetic foot ulcers and gait-balance impairment can also be managed with physiotherapy (Kaur and Singh, 2022).

2.7 Relevant Anatomy

The Lower extremity muscles

The muscles of the lower limb can be divided into four regions: the gluteal, thigh, leg and foot region.

Muscles of the gluteal region

The muscles in this region are organized into two layers: the superficial and deep layer. The muscles in the superficial layer are the gluteus maximus, gluteus medius, gluteus minimus and tensor fascia latae. These muscles originate from the ilium and insert on the femur except the tensor fascia latae which inserts on the tibia. They function as the extensors, abductors and medial rotators of the thigh. The muscles in the deep layer are the piriformis, obturator internus, superior and inferior gemelli, and quadratus femoris. They are the lateral rotators of the thigh (Moore et al., 2013).

Muscles of the thigh

The thigh region comprises of the anterior, medial and posterior thigh region. Muscles of the anterior compartment of the thigh are the quadriceps femoris, sartorius, pectineus, iliacus and psoas major.

Iliacus and psoas major

The Iliacus originate from the iliac fossa of the pelvis while the psoas major originate from the lumbar vertebrae, they both insert at the lesser trochanter of the femur and their action is to flex the thigh at the hip joint (Chaurasia, 2013).

Pectineus

This muscle originate from the superior ramus of the pubis and insert at the pectineal line of the femur, it's action is to adduct and flex the thigh (Moore et al., 2013)

Sartorius

The sartorius is the longest muscle in the body, it originates from the anterior superior iliac spine and inserts at the superior part of medial surface of the tibia. It's action is to flex, abduct, laterally rotate the thigh at the hip joint and flex the leg at the knee joint (Singh, 2014).

Quadriceps femoris

The quadriceps femoris consists of four muscles; vastus lateralis, vastus intermedius, vastus medialis and rectus femoris.

The proximal attachment of the vastus lateralis is the greater trochanter and lateral lip of linea aspera of the femur, the vastus medialis originates from the intertrochanteric line and medial lip of linea aspera of femur, vastus intermedius originates from the anterior and lateral surfaces of the shaft of the femur while the rectus femoris originates from the anterior inferior iliac spine and ilium superior to the acetabulum. These four muscles all insert at the patella via a common tendon called the quadriceps tendon. The action of the quadriceps femoris is to extend the leg at the knee joint, the rectus femoris also assist the iliopsoas to flex the thigh (Moore et al., 2013).

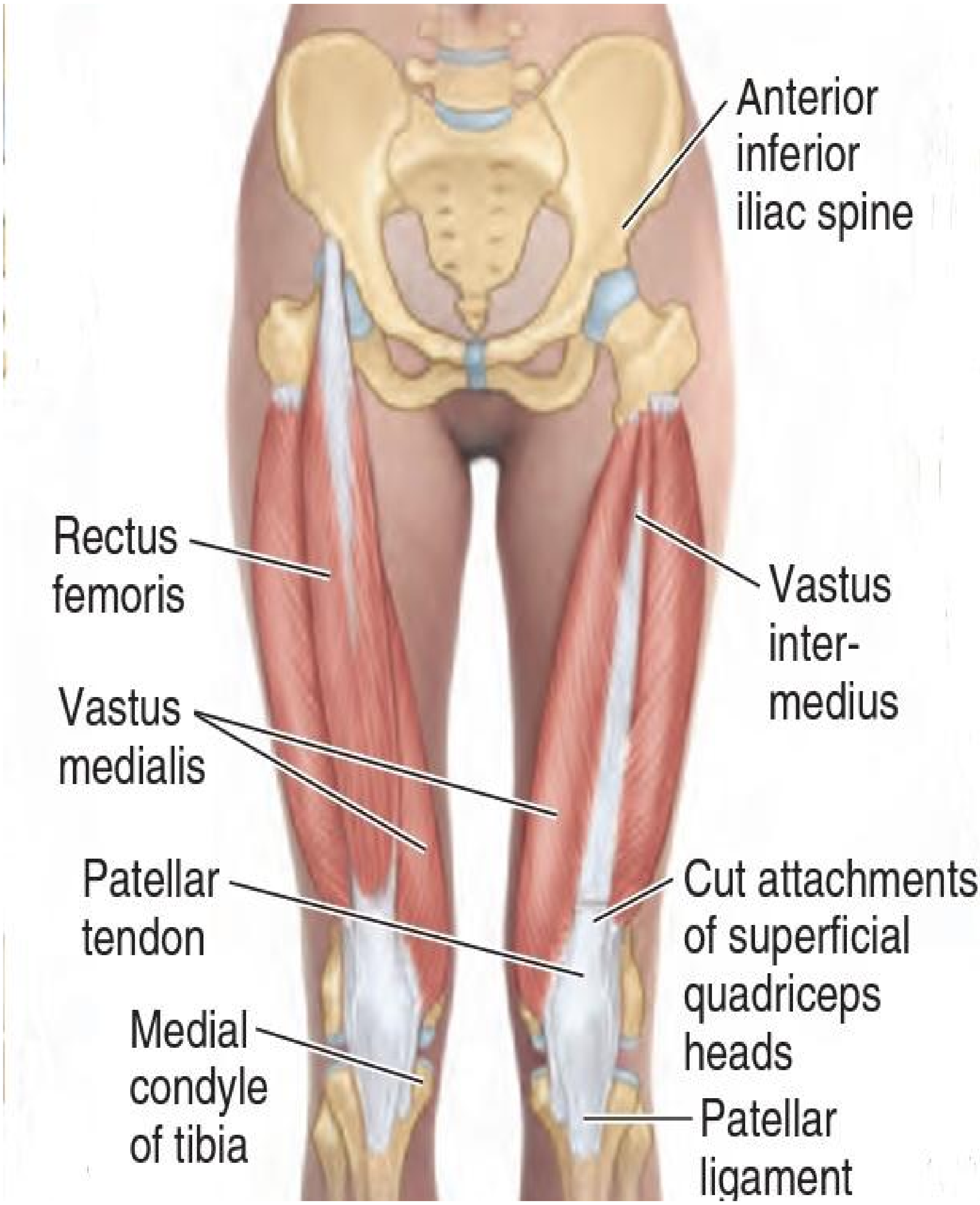

Figure 1 Muscles of the anterior thigh (Moore et al., 2013).

Image source: Moore, Clinically Oriented Anatomy. 7th Edition. Pg. 547.

Muscles of the medial component are the adductor longus, adductor brevis, adductor magnus, gracilis and obturator externus. Adductor longus, brevis, magnus and gracilis all originate from the pubis and inserts at the femur except gracilis which inserts at the tibia, they all act to adduct the thigh while the obturator externus laterally rotates the thigh (Houglum and Bertoti, 2011).

Muscles of the posterior compartment are called the hamstring muscles which comprise of three muscles; semitendinosus, semimembranosus and biceps femoris. The origin of the semitendinosus, semimembranosus and long head of the biceps femoris is the ischial tuberosity while the short head of the biceps femoris originates from the lateral lip of the linea aspera and the lateral supracondylar line of femur. The hamstrings are the chief flexors of the knee joint and weak extensors of the hip joint (Singh, 2014).

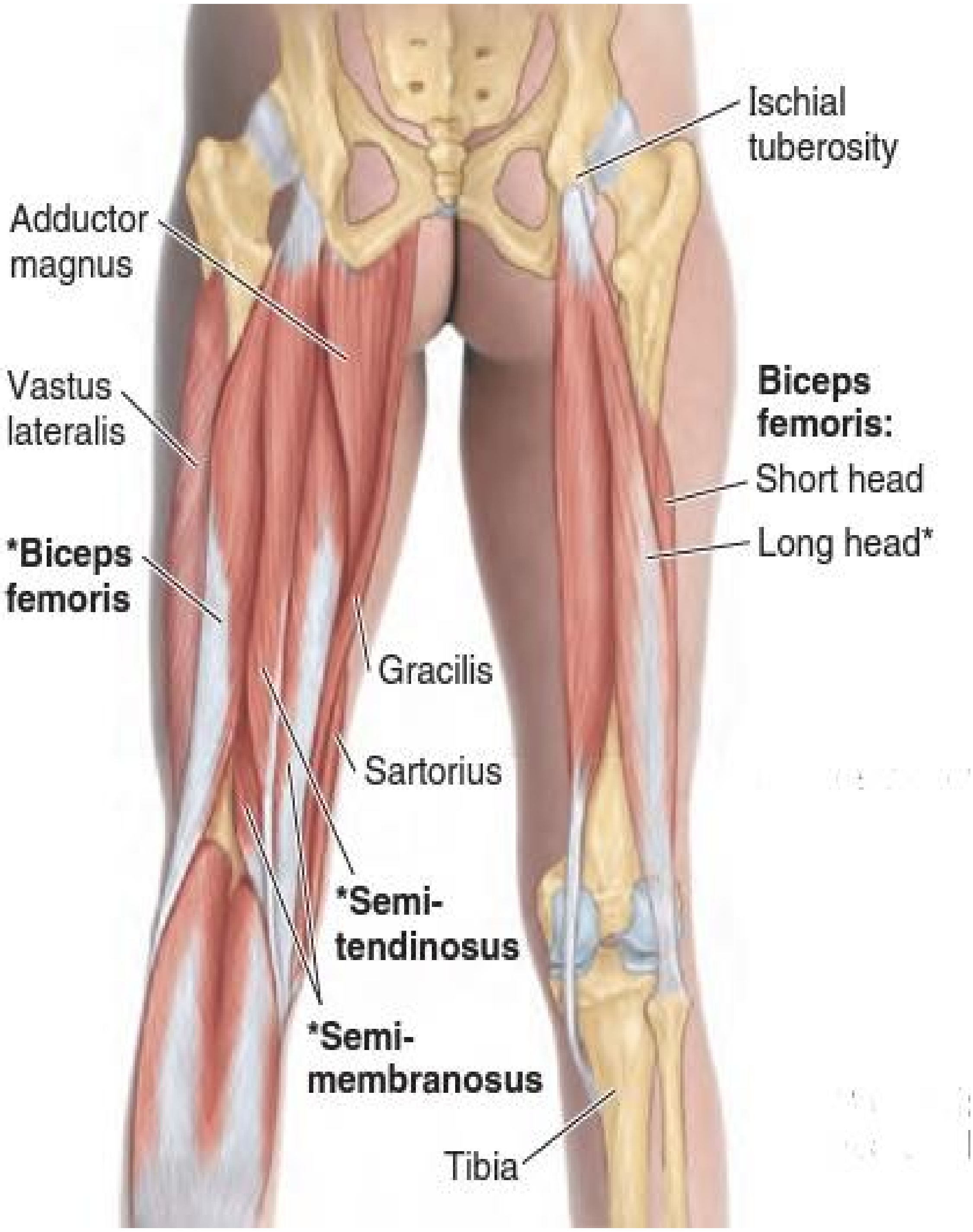

Figure 2 Muscles of the posterior thigh (Moore et al., 2013).

Image source: Moore, Clinically Oriented Anatomy. 7th Edition. Pg. 570.

Muscles of the leg

The leg muscles can be divided into three compartments: the anterior compartment, lateral compartment and posterior compartment.

Muscles of the anterior compartment of the leg

The muscles present in this compartment are: tibialis anterior, extensor digitorum longus, extensor hallucis longus, and fibularis tertius (Moore et al., 2013). All these muscles originate from the fibula except the tibilias anterior which originates from the tibia, they are all supplied by the deep peroneal nerve (Singh, 2014).

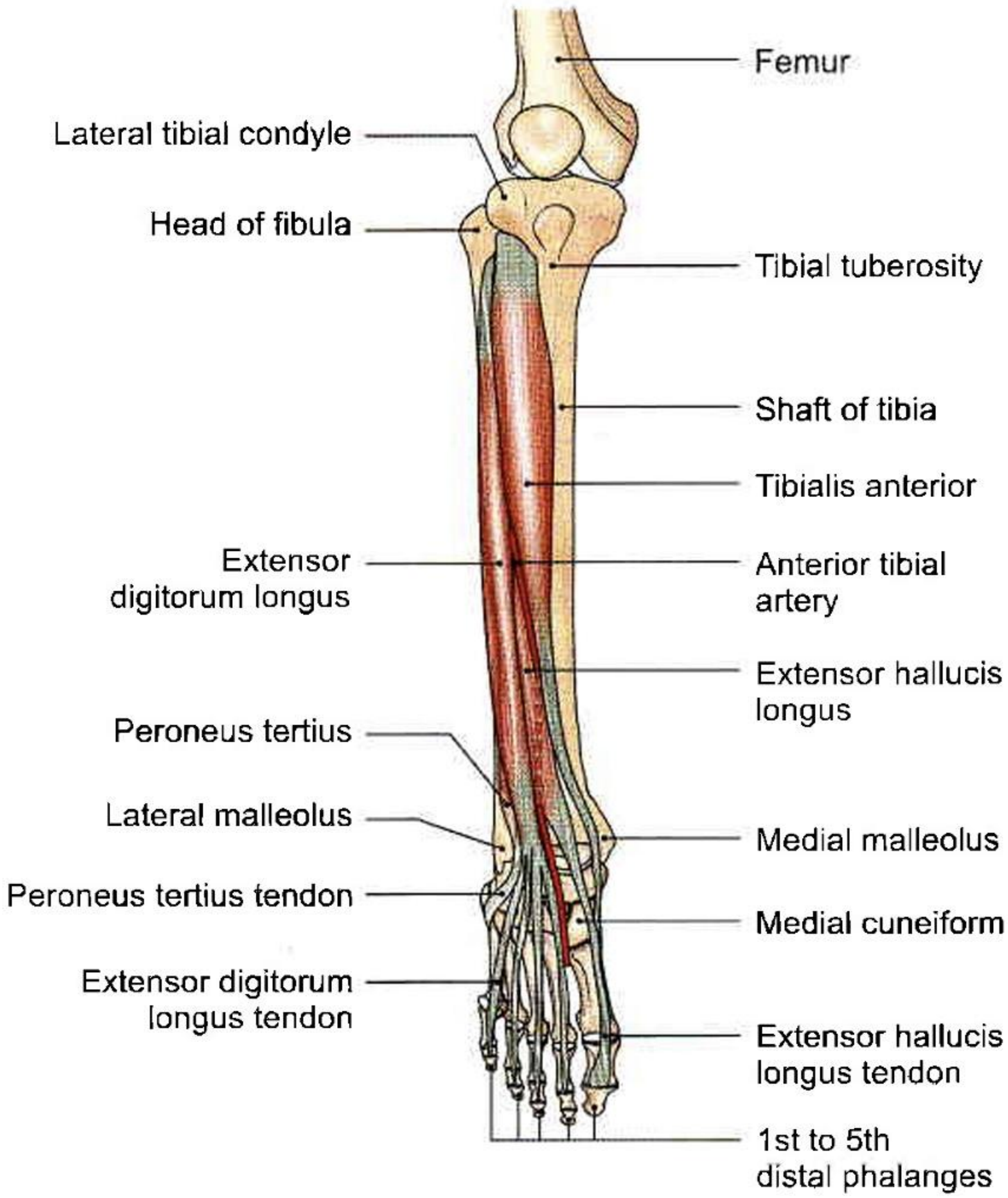

Figure 3 Muscles of the anterior compartment of the leg (Chaurasia, 2013).

Image source: Chaurasia, Human Anatomy. 6^{th} Edition. Pg. 94.

Tibilais Anterior

The tibialis anterior (TA), the most medial and superior dorsiflexor, is a thin muscle that runs along the lateral side of the tibia (Moore et al., 2013).

It originates from the upper two-thirds of the lateral surface of the tibia, the interosseous membrane and the overlying deep fascia of the leg and inserts into the inferomedial side of the base of the first metatarsal bone and the adjacent part of the medial cuneiform; its nerve supply is the deep peroneal nerve while the blood supply is the anterior tibial artery; this muscle dorsiflexes the foot, inverts the foot at the mid tarsal and subtalar joint and maintains the medial longitudinal arch (Singh, 2014).

The test for TA is to dorsiflex or stand on your heels against resistance; normal action will cause the tendons to be seen and palpated (Moore et al., 2013).

Extensor Digitorum Longus

The Extensor digitorum (EDL) is located laterally and it forms four tendons that attach to the phalanges of the lateral four toes (Moore et al., 2013). It originates from the lateral condyle of the tibia, upper 1/4th of the fibula, upper part of interosseous membrane and inserts into the lateral four toes; its nerve supply is the deep peroneal nerve while the blood supply is the anterior tibial artery; this muscle dorsiflexes the foot, extends the metatarsophalangeal (MP), proximal interphalangeal, and distal interphalangeal joints of the four toes (Chaurasia, 2013).The test for EDL is to dorsiflex the lateral four toes against resistance; normal action will cause the tendons to be seen and palpated (Moore et al., 2013).

Extensor hallucis longus

The extensor hallucis longus (EHL) is a slender muscle that lies deep in between the tibialis anterior and extensor digitorum longus (Moore et al., 2013). It originates from the middle of the anterior surface of fibula and interosseous membrane and inserts into the dorsal part of base of distal phalanx of great toe (hallux); its nerve supply is the deep peroneal nerve while the blood supply is the anterior tibial artery; this muscle dorsiflexes the ankle and extends the great toe (Moore et al,. 2013). The test for this muscle is to dorsiflex the great toe against resistance; normal action will cause the tendon to be seen and palpated (Moore et al., 2013).

Fibularis tertius

The fibularis tertius muscle shares synovial sheath with the extensor digitorum longus (Moore et al,. 2013). It may have a unique proprioceptive function, recognizing sudden inversion and contracting reflexively to protect the anterior tibiofibular ligament, the most often injured ligament in the body, but in some cases, this muscle might be absent (Moore et al,. 2013). It originates from the interosseous membrane and lower 1/4th of the anterior surface of the fibula and inserts into the dorsum of the base of the 5th metatarsal bone; the nerve supply is the deep peroneal nerve while the blood supply is the anterior tibial artery; this muscle everts and dorsiflexes the foot (Singh, 2014).

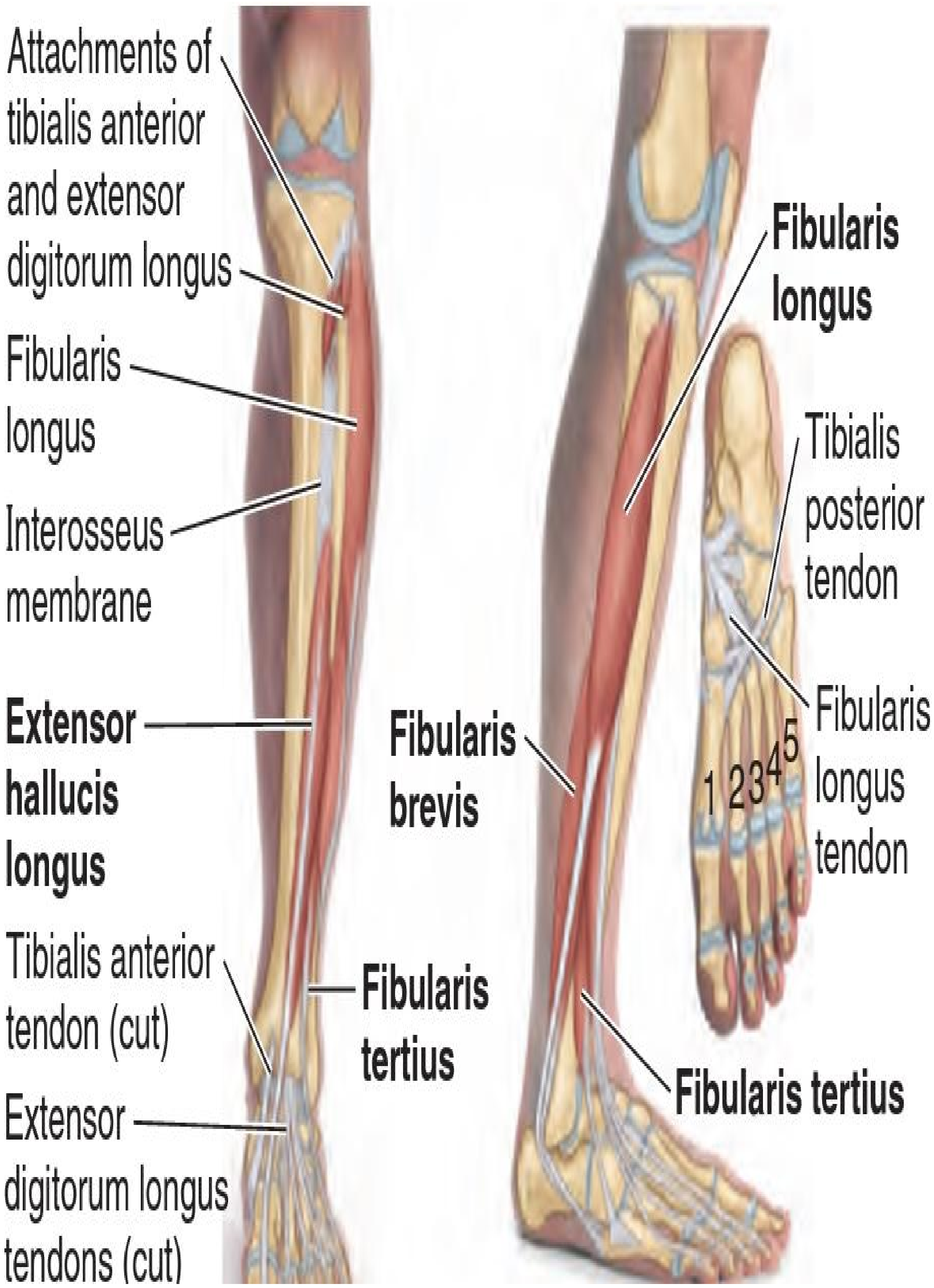

Figure 4 Muscles of the anterior and lateral compartment of the leg (Moore et al., 2013).

Image source: Moore, Clinically Oriented Anatomy. 7th Edition. Pg. 591,

Muscles of the lateral compartment of the leg

The muscles present in this compartment are: fibularis longus and fibularis brevis. They are known as the evertors of the foot acting at the subtalar and transverse tarsal joints (Moore et al., 2013).

Test for fibularis longus and fibularis brevis: evertion of the foot against resistance; normal action will cause the muscle tendons to be seen and palpated inferior to the lateral malleolus (Moore et al., 2013).

Fibularis longus

The fibularis longus, also known as the peroneus longus is more superficially located, longer and larger than the fibularis brevis (Singh, 2014).

It originates from the upper two thirds of the lateral surface of fibula and inserts into the medial cuneiform and 1st metatarsal base; the nerve supply is the superficial fibular nerve while the blood supply is anterior tibial artery; this muscle weakly planterflexes the ankle and everts the foot (Chaurasia, 2013).

Fibularis brevis

Fibularis brevis is a fusiform bipennate muscle that is shorter than the fibularis longus and lies deep to it (Singh, 2014). It originates from the lower two-third of lateral surface of the shaft of the fibula and inserts into the tubercle on the lateral side of the base of the fifth metatarsal; the nerve supply is the superficial fibular nerve while the blood supply is the anterior tibial artery; this muscle acts to maintain the lateral longitudinal arch and everts the foot (Singh, 2014).

Muscles of the posterior compartment of the leg

The posterior compartment of the leg is the largest of the three compartments and the muscles in this compartment are the bulkiest as it contains large powerful antigravity muscles (gastrocnemius and soleus), muscles in this compartment are divided by the transverse intermuscular septum into superficial and deep muscle groups (Moore et al., 2013; Singh, 2014). Actions produced by the muscles of the posterior compartment are plantarflexion of the ankle, flexion of the toes and inversion at the subtalar and transverse tarsal joints (Moore et al., 2013).

Superficial muscles of the posterior compartment of the leg

The muscles in this subcompartment are gastrocnemius, soleus and plantaris, they are known as the calf muscles (Moore et al., 2013). Both the gastrocnemius and the soleus end with the calcaneal tendon which attach the muscles to the calcaneus (Moore et al., 2013). The muscles of this group are said to be heavy and strong because of the action they carry out which is to accelerate the weight of the body when walking, lifting, propelling, running, jumping, or standing on the toes (Moore et al., 2013).

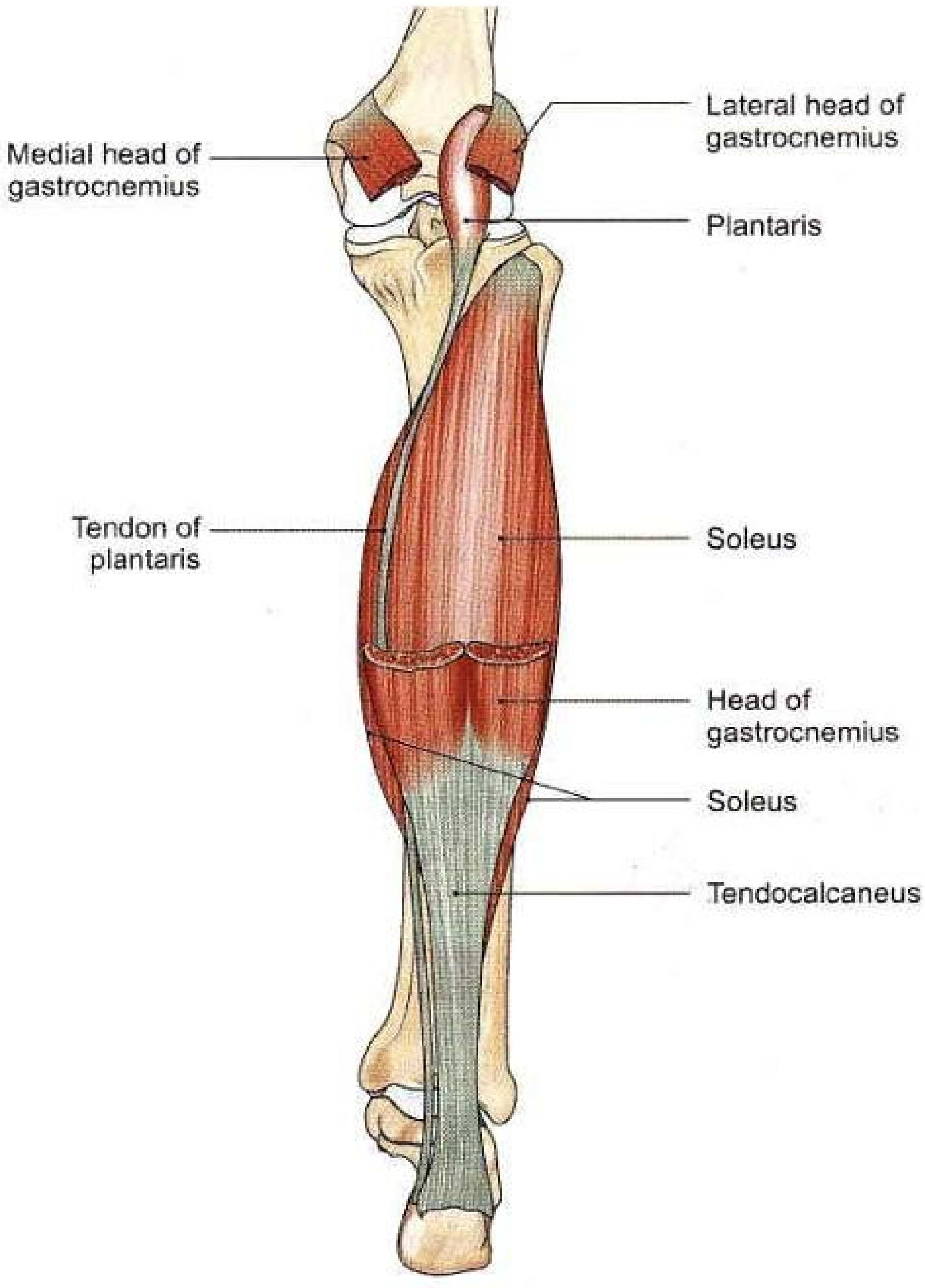

Figure 5 Superficial muscles of the posterior compartment of the leg (Chaurasia, 2013).

Image source: Chaurasia, Human Anatomy. 6^{th} Edition. Pg. 107.

Gastrocnemius

This muscle is the most superficial and largest of all the muscles in the posterior compartment, it has both medial and lateral heads (Singh, 2014).

The lateral head originates from the lateral aspect of lateral condyle of femur while the medial head originates from the popliteal surface of femur and the superior to medial condyle, it inserts into the posterior surface of calcaneus through the calcaneal tendon; the nerve supply of this muscle is the tibial nerve while the blood supply is lateral and medial sural arteries; it plantarflexes the foot at the ankle joint and flexes the knee (Chaurasia, 2013).

Soleus

The soleus is a large, flatter muscle located beneath the gastrocnemius and is referred to as the “workhorse” of plantarflexion (Moore et al., 2013). When a person is standing on his toes, the soleus can be palpated on each side of the gastrocnemius (Moore et al., 2013). To maintain the balance of the leg, the soleus contracts antagonistically but cooperatively with the dorsiflexor muscles (Moore et al., 2013).

The soleus originates from the soleal line and middle one third of the medial border of the tibia; posterior aspect of the head and upper one-fourth of the posterior surface of the shaft of fibula; tendinous soleal arch between the fibula and tibia, it inserts into the middle one-third of the posterior surface of the calcaneus through the calcaneal tendon; its nerve supply is the tibial nerve while the blood supply is the posterior tibial artery and peroneal artery; this muscle planterflexes the ankle and stabilzes the leg during standing (Singh, 2014).

Plantaris

This is a small muscle with a long tendon and a short belly, it is not present in everyone (Moore et al., 2013). It is known to sometimes rupture suddenly with a painful pop during activities such as racquet sports (Moore et al., 2013).

It originates from the lower part of the lateral supracondylar line; oblique popliteal ligament and inserts into the posterior surface of calcaneus through the calcaneal tendon; its nerve supply is the tibial nerve while the blood supply is the lateral sural artery and superior lateral genicular artery; this muscle weakly assists gastrocnemius in plantarflexing ankle (Chaurasia, 2013).

Deep muscles of the posterior compartment of the leg

The four muscles in this compartment are popliteus, flexor digitorum longus, flexor hallucis longus, and tibialis posterior.

Popliteus

The popliteus is a flat, thin, triangular muscle, that forms the lower part of the floor of the popliteal fossa (Singh, 2014). It originates from the lateral surface of lateral condyle of femur and lateral meniscus of the knee and inserts into posterior surface of tibia above the soleal line; its nerve supply is the tibial nerve while the blood supply is the inferior medial and lateral genicular arteries; this muscle unlocks the knee joint by lateral rotation of femur on tibia prior to flexion (Chaurasia, 2013).

Flexor digitorum longus

The flexor digitorum longus moves four digits but it is smaller in size than the flexor hallucis longus (Moore et al., 2013). It originates from the upper two-third of the medial part of the posterior surface of the tibia below the soleal line and the fascia covering the tibialis posterior and inserts into the plantar surface of the base of distal phalanges of the lateral four toes; tibial nerve and posterior tibial artery sipplies this muscle; its action is plantarflexeion of the lateral four toes and ankle and to maintain the longitudinal arches of the foot (Singh, 2014).

Flexor hallucis longus

FHL is the main flexor of all of the joints of the great toe (Moore et al., 2013). It originates from the lower three-fourth of the posterior surface of the shaft of the fibula, behind the medial crest and posterior interosseous membrane and inserts into the plantar surface of the base of distal phalanx of great toe; the nerve supply is the tibial nerve while the blood supply is the posterior tibial artery; this muscle plantar flexes the great toe and the ankle and supports the medial longitudinal arch of the foot (Singh, 2014).

Tibialis posterior

Tibialis posterior is the deepest muscle in the posterior compartment, it lies between the FDL and the FHL in the same plane as the tibia and fibula within the deep subcompartment (Moore et al., 2013). It originates from the upper two-third of the posterolateral surface of tibia below the soleal line, posterior surface of the fibula in front of the medial crest, upper two-third of the posterior surface of the interosseous membrane and inserts into the tuberosity of the navicular bone and bases of the 2nd to 4th metatarsals; its nerve is the tibial nerve while the blood supply is the posterior tibial artery; this muscle plantarflexes the ankle, inverts the foot and supports the medial longitudinal arch of the foot (Chaurasia, 2013).

2.8 Lower Extremity Strength

Lower extremity strength is the amount of maximal force generated by the muscles of the lower limb in one single contraction (Strollo et al., 2022). The strength of the lower limb muscles can be measured using a dynamometer (Strollo et al., 2022).

In a type 2 diabetes state, the aging-related loss of muscle strength is accelerated (Leenders et al., 2013). In a study conducted by Leenders et al., (2013), it was reported that muscular strength of the type 2 diabetes group and the normoglycemic control group was significantly different.

The result of a study conducted by Park et al., (2006) showed that although type 2 diabetic older persons had more muscle mass in their arms and legs than did those without the disease, their muscle strength was lower, this was an unexpected discovery because muscle mass had previously been thought to be the main factor of muscle strength.

Andersen et al., (2004) also found out that there is muscle weakness at the ankle and knee in patients with type 2 DM, this weakness is related to diabetic polyneuropathy which is common in T2DM. Since lack of physical activity is one of the risk factors for the development of T2DM, it is also possible that inactivity and disuse of the muscles contribute to the relative weakness of lower extremity strength (Ijzerman et al., 2011).

Walking, ascending stairs, and rising from a seated position all require Leg Extensor Power (LEP) therefore it is important that leg muscle strength be maintained throughout life as this may lessen the incidence of falls and the related sprains and fractures (Oke et al., 2009).

2.9 Quality of life

The term 'quality of life' describes both the good and bad part of a person's life, it describes the whole nature of a person's life and his/her ability to maintain or improve their QOL (Farquhar, 1995). Quality of life is both subjective and multidimensional, because of it's subjective nature, it is best measured from the patient's point of view and because it is multidimensional, measuring it necessitates asking the patient about a variety of aspects of their life, such as their physical health, functional capacity, mental health, and social health (Cella, 1994).

QOL measures are used to quantify the impact of an illness, to assess changes caused by treatment intervention or illness progression and it is also a critical component of cost/effectiveness analysis (Kaplan and Ries, 2007). Data on quality of life can be used to assess the cost-effectiveness or cost/utility of health-care services (Kaplan and Ries, 2007).

Health Related Quality of Life (HRQoL) is concerned with health aspects while also taking into consideration general QoL components (Theofilou, 2013). HRQoL can be assessed using various instruments, usually in the form of questionnaires and changes in HRQoL are now considered an essential result of DM treatment therapies (Rodríguez-Almagro et al., 2018).

People with diabetes have to go through extra effort every day to take their medications or insulin, modify their lifestyle, monitor their diet and blood glucose level; all these takes a toll on them psychologically thereby causing a negative impact on their quality of life and this is one of the reasons why individuals with diabetes have reduced QOL, this affects their happiness, satisfaction and social participation (Colak, 2016). Furthermore, diabetes patients have a significantly higher prevalence of depression than people without the disease, this depression lowers quality of life and makes therapy more difficult (Wexler et al., 2006).

In a study conducted by Wexler et al., (2006), it was reported that even in the absence of socioeconomic challenges, medical complications, or depressive symptoms, a patient with type 2 diabetes has a minimally impaired health-related quality of life; these findings show that the best ways to help type 2 diabetes patients live healthier lives or improve their QOL are by addressing their depression and preventing complications.

2.10 Movement performance capacity

Numerous complications from diabetes have a detrimental effect on the musculoskeletal system and a person's ability to engage in a variety of daily physical activities (Reeves et al., 2013). Decreased functional limitations and impairment in older persons with type 2 diabetes is due to the reduced muscle strength or poor muscular function as this is a sign of physical disability (Park et al., 2006). Patients with type 2 diabetes who have weak lower limb muscles experience difficulty moving, have slower gait speed, shorter step length, difficulty maintaining their balance, increased postural sway and are more likely to fall (Kraiwong et al., 2019; Awotidebe et al., 2016; Fulk et al., 2010).

Muscular weakness, reduced joint range of motion, foot and body pain, pharmacological complications, specialty (offloading) footwear devices and peripheral nerve injury (neuropathy) impairs physical function, therefore, affected individuals typically walk more slowly and with greater gait irregularity, which increases their risk of falling (Reeves et al.,2013). It has been reported that 39% of older people with diabetes experience falls every year (Reeves et al., 2013).

2.1 Summary of empirical literature

Study	Title of the study	Study Objective	Method	Conclusion
Ijzerman et al., (2011)	Lower extremity muscle strength is reduced in people with type 2 diabetes, with and without polyneuropathy, and is associated with impaired mobility and reduced quality of life.	The purpose of this study was to distinguish the effects of both diabetes mellitus type 2 (DM2) and diabetic Polyneuropathy (DPN) on mobility, muscle strength and health related quality of life (HR-QoL).	98 DPN patients, 39 patients without DPN and 19 healthy subjects participated in this study. They performed isometric and isokinetic lower limb muscle strength tests. Mobility was determined by a timed up and go test (TUGT), a 6 min walk test and the physical activity scale for the elderly questionnaire. HR-QoL was determined by the SF36 questionnaire.	DM2 patients, with and without DPN, have decreased maximal muscle strength in the lower limbs and impaired mobility. These abnormalities are associated with a loss of HR-QoL.
Oke et al., (2009)	Weight bearing index and gait speed as valid predictors of functional performance capacity in patients with type 2 diabetes mellitus.	The purpose of this study was to establish the correlation between the weight bearing index and gait speed as possible predictors of functional performance capacity and quality of life in patients with type 2 diabetes mellitus.	15 T2DM patients particpited in this study. Their weight was measured using a weighing scale while a dynamometer was used to measure leg strength. The weight bearing index was calculated from the knees extensors muscle strength/ body weight. Gait speed was calculated by dividing the 15.2m brisk walk done by the subject with the time (s) it took him/ her to execute it.	Weight bearing index and gait speed are significant predictors of functional performance capacity of patients with type 2 diabetes mellitus.

Andersen et al., (2004)	Muscle strength in type 2 diabetes.	To determine the muscle strength of patients with type 2 diabetes.	36 type 2 DM patients and 36 control subjects participated in this study. Sociodemographics data were taken for both groups, strength of flexors and extensors at elbow, wrist, knee, and ankle was assessed at isokinetic dynamometry. Degree of neuropathy was determined by clinical scores, nerve conduction studies, and quantitative sensory testing.	Type 2 diabetic patients may have muscle weakness at the ankle and knee related to presence and severity of peripheral neuropathy.
Kraiwong et al., (2019)	Effect of sensory impairment on balance performance and lower limb muscle strength in older adults with type 2 diabetes.	To compare balance performance and lower limb muscle strength between older adults with type 2 diabetes mellitus (DM), with and without sensory impairments and non-DM groups.	92 older adults with and without type 2 DM, were examined relative to visual function with the Snellen chart, Melbourne Edge test, and Howard-Dolman test, vestibular function with the modified Romberg test, proprioception of the big toe, and diabetic peripheral neuropathy with the Michigan Neuropathy Screening Instrument. Balance performances were evaluated with the Romberg test, Functional Reach Test (FRT), and Timed Up and Go test	There were significant differences, of muscle strength and balance performance among groups. Poorer balance and reduced lower limb strength were marked in older adults with type 2 DM, even ones without sensory impairment. Muscle weakness seemed to progress, from the distal part of lower limbs. A greater number of sensory impairments, weaker dorsiflexors, and advanced age influenced balance performance.

			(TUG). Strength of knee and ankle muscles was measured.	
Awotidebe et al., (2016)	Relationships among exercise capacity, dynamic balance and gait characteristics of Nigerian patients with type-2 diabetes: an indication for fall prevention	To investigate the relationships among exercise capacity, dynamic balance and gait characteristics of patients with type-2 diabetes and healthy controls	This observational controlled study involved 125 patients with T2DM receiving treatment at a Nigerian university teaching hospital and 125 apparently healthy patients' relatives and hospital staff recruited as controls. Dynamic balancd and gait characteristics were assessed using the Time Up to Go Test and an accelerometer (BTS G-Walk) assessing gait speed, step length, stride length, and cadence respectively during a self-selected walk.	Patients with T2DM demonstrated unstable dynamic balance, and altered gait characteristics compared with healthy controls.
Rodriguez-Almagro et al., (2018)	Health-related quality of life in diabetes mellitus and its social, demographic and clinical determinants: A nationwide cross-sectional survey	To investigate health-related quality of life in a representative sample of adults with diabetes mellitus in Spain, as well as its clinical and sociodemographic determinants.	A validated Spanish-language version of the self-administered Diabetes quality of life questionnaire was used, with 0 being the worst and 100 the best QoL level. Determinant factors of health-related quality of life were assessed with the aid of multivariate analysis to control for confounding factors.	Overall health-related quality of life perception in the Spanish diabetic population is moderate and depends on several sociodemographic factors.

Park et al., (2009)	Decreased muscle strength and quality in older adults with type 2 diabetes: The health, aging, and body composition study	To determine the muscle strength and quality in older adults with type 2 diabetes mellitus	The muscle strength and knee extension of 485 older adults was evaluated using the isokinetic and isometric dynamometer respectively.	Type 2 diabetes is associated with lower skeletal muscle strength and quality
Kaur and Singh, (2022).	Role of physiotherapy in Managing type 2 Diabetes Mellitus. A Systematic Review	To systematically review the current evidence on role of physiotherapy in type 2 diabetes patients.	The systematic review was conducted and reported in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines	Physiotherapy is a beneficial non-pharmacological treatment and it can improve optimal physical, QOL psychological health of diabetic patients and can reduce the chances of morbidity and mortality by managing the complications of T2DM.
Wexler et al., (2006)	Correlates of health-related quality of life in type 2 diabetes	To investigate the impact of medical comorbidities, depression, and treatment intensity on quality of life of patients with type 2 diabetes.	Health Utilities Index-III, was used to measure health-related quality of life in 909 primary care patients with type 2 diabetes.	Patients with type 2 diabetes have a substantially decreased quality of life in association with symptomatic complications
Leenders et al., (2013)	Patients with type 2 diabetes show a greater decline in muscle mass, muscle strength, and functional capacity with aging	To investigate the impact of type 2 diabetes on muscle mass, strength, and functional capacity in an older population.	Muscle mass, strength and functional capacity of 60 older men with type 2 diabetes were assessed using muscle biopsies, 1-repetition maximum and sit-to-stand test respectively and were compared with 32 age-matched normoglycemic controls	Older patients with type 2 diabetes show an accelerated decline in leg lean mass, muscle strength, and functional capacity when compared with normoglycemic controls

Fulk et al., (2010)	The effects of diabetes and/or peripheral neuropathy in detecting short postural perturbations in mature adults	To determine the effects of diabetes mellitus (DM) and peripheral neuropathy (PN) on the ability to detect near-threshold postural perturbations.	83 subjects participated in this study; 32 with type II DM (25 with peripheral neuropathy (PN) and 7 without PN), 19 with PN without DM, and 32 without DM or PN. Peak acceleration thresholds for detecting anterior platform translations of 1 mm, 4 mm, and 16 mm displacements were determined.	PN may not be the only cause of impaired balance in people with DM. Diabetes itself might negatively impact the postural control system.
Strollo et al., (2022)	A review of the relationship between leg power and selected chronic disease in older adults	To investigate the relationship between leg muscle power and chronic conditions in older adults	A search was performed using PubMed to identify original studies published in English from January 1998 to August 2013. Leg power studies, among older adults ≥ 50 years of age, which assessed associations with chronic conditions such as osteoarthritis, diabetes mellitus, and/or cardiovascular disease were selected.	Studies suggest that these chronic conditions are associated with lower leg power compared to older adults without these conditions.

CHAPTER 3

MATERIALS AND METHOD

3.1 Participants

3.1.1 Participants Selection

This study was conducted among males and females type 2 diabetes mellitus patients in University of Benin Teaching Hospital (UBTH).

3.1.2 Inclusion Criteria

The following participants were included in this study:

Male and female type 2 DM out-patients in UBTH;

i. from ages 65 years and above.

ii. with good cognition.

iii. who gave consent to this research.

3.1.2 Exclusion Criteria

The following participants were excluded from this study:

Male and female type 2 DM out-patients in UBTH;

i. with cognitive impairment.

ii. with visual impairment

iii.who did not give consent to this research.

iv. with foot ulcers.

v. with other comorbidities such as stroke or amputees.

3.2 Materials

3.2.1 Apparatus/ Instruments

i. Improvised leg dynamometer

The improvised leg dynamometer is used to measure lower limb muscle strength. The dynamometer was attached to the participant's ankle joint by a strap while the leg is stretched to 60 degrees, this was done with the participant sitting on an arm rest chair and grasping the arm rest in order for the body to be fixed (Oke et al., 2009).

ii. World Health Organisation Quality Of Life Brief Version (WHOQOL-BREF) Questionnaire:

The WHOQOL-BREF questionnaire is a 26-item questionnaire which generates scores for four quality of life domains namely physical health, psychological health, social relationships, and environment, it also has one aspect dealing with overall quality of life and general health (Whoqol Group, 1998; Cheung et al., 2017). Each of the items in this questionnaire are rated on a response scale ranging from 1 to 5 on a five-point likert scale (Reba et al., 2019). The WHOQOL-BREF is said to be most effective in investigations that need a quick assessment of quality of life, such as clinical trials where quality of life is of interest; this questionnaire may also be useful to health practitioners in assessing and evaluating therapy efficacy (Whoqol Group, 1998).

The WHOQOL-BREF questionnaire is a subjective assessment of an individual's perception of their life positions in respect to their objectives, expectations, standards, and worries, as well as the culture and value systems in which they live (Cheung et al., 2017). Cronbach's

Alpha was used to assess the reliability of the WHOQoL- BREF domains and a score of 0.70 and higher was acceptable (Gholami et al.,2013).

iii. Short Physical Performance Battery

The Short Physical Performance Battery (SPPB) is a well-known tool for assessing the physical performance of the lower extremities, it includes three different segments which are; assessment for balance time, walking speed, and chair stand (Pavasini et al., 2016). The SPPB consists of three tests: a hierarchical evaluation of standing balance, a brief walk at the elderly's speed, and five times standing up from a chair. Participants were instructed to maintain their balance while standing with their feet as close together as possible, then in a semi-tandem position with one foot's ankle behind the joint of the other foot, and finally in a tandem position with one foot's ankle touching the other foot, this posture was held for 10 seconds. For gait speed, the time needed to go 3 meters at a regular rate was recorded. For the standing test from a chair, participants were instructed to stand and sit in a chair five times as promptly as they could while keeping their arms crossed over their chests. But this test was conducted only when the elderly person had shown that he/she can stand up without using their arms (Gomez et al., 2013).

In a study conducted by Freire et al., (2012), the reliability and validity of SPPB in various populations was proven. Gomez et al., (2013) proved that the Test- retest reliabilty of SPPB was high : 0.87 (Cl95% : 0.77-0.96).

3.3 Methods

3.3.1 Sampling Technique

A purposive sampling technique was used for this study.

Sample size

The sample size is calculated using the Taro Yamane's formula.

$n = N / (1+ N [e]^2)$

Where;

n = sample size

N = population size (286)

e = margin of error (0.05)

Using the parameters; $n = 286/ (1+ 286 [0.05]^2)$

$n = 166.76$

The sample size is approximately 167.

3.3.2 Research Design

A cross sectional survey research design was used in this study.

3.3.3 Procedure for data collection

The data for this study was collected using the World Health Organisation Quality Of Life (WHOQOL-BREF) Questionnaire. 167 T2DM patients from 65 years and above were recruited to complete this questionnaire.

3.3.4 Procedure for Assessment/ Measurements

The short physical performance battery was used to assess the movement performance capacity of the T2DM patients, patients were given instructions on the task to carry out and scored based on how they perform.

The lower extremity strength was measured using the improvised leg dynamometer. The patient sits on a comfortable chair with an arm rest and was asked to stretch their leg while the dynamometer takes the required measurement.

3.3.5 Ethical Consideration

Ethical approval for this study was sought for and obtained (ADM/E 22/A/VOL.VII/148301179) from the Ethics Research Committee of University of Benin Teaching Hospital (UBTH), Benin City. Prospective participants were adequately informed about the aims, methods, any possible conflicts of interest, institutional affiliations of the researcher, the anticipated benefits and potential discomfort it may entail. Afterwards, participants were reserved with the right to refuse to participate without reprisal.

3.3.6 Data Analysis

All data were analyzed using descriptive statistics of mean, frequency and standard deviation. Inferential statistics of Pearson's correlation coefficient test was used to analyze the relationship between LES and movement performance capacity, Spearman's rank correlation coefficient test was used to analyze the relationship between LES and quality of life of patients with T2DM. All inferential analyses were performed at 0.05 alpha levels.

Data was analyzed using the International Business Machine (IBM) Statistical Package for Social Sciences (SPSS) version 24.0.

CHAPTER FOUR

RESULTS

4.1 Preamble

The main aim of this study was to determine the relationship between lower extremity strength, quality of life and movement performance capacity in patients with Type 2 DM. A total of 167 respondents were recruited for this study from the University of Benin Teaching Hospital.

4.1.1 Sociodemographic characteristics and clinical data of the respondents

As shown in table 1. 90 (53.9%) of the respondents were female, 72 (43.1%) of the respondents had secondary level of education. 119 (71.3%) of the respondents were married, 123 (73.7%) were Christians. 94 (56.3%) were of low economic status. 101 (60.5%) have had Type 2 DM for a duration of more than 2 years. 149 (89.2%) do not smoke, 105 (62.9%) reported having comorbidities and 68 (40.7%) reported having complications of Type 2 DM. 134 (80.2%) of the respondents had a moderate glycemic index, 132 (79.0%) receive insulin via oral administration. 117 (70.1%) of the respondents had moderate severity of symptoms.

Table 1: Sociodemographic characteristics and clinical data of the respondents **N = 167**

	Frequency	Percentage (%)
Gender		
Male	77	46.1
Female	90	53.9
Level of Education		
Primary	39	23.4
Secondary	72	43.1
BSc	35	21.0
MSc	10	6.0
PhD	11	6.6
Marital Status		
Single	40	24.0
Married	119	71.3
Divorced	8	4.8
Religion		
Christian	123	73.7
Muslim	44	26.3
Socioeconomic status		
Low	94	56.3
Medium	65	38.9
High	8	4.8
Duration		
6 months – 1 year	23	13.8
1 – 2 years	43	25.7
>2 years	101	60.5
Do you smoke?		
Yes	18	10.8
No	149	89.2
Comorbidities		

Yes	105	62.9
No	62	37.1
Complications		
Yes	68	40.7
No	99	59.3
Glycemic Index		
Low	18	10.8
Moderate	134	80.2
High	15	9.0
Insulin Intake		
Oral	132	79.0
Injection	19	11.4
Both	16	9.6
Severity		
Mild	21	12.6
Moderate	117	70.1
Severe	29	17.4

4.1.2 Lower extremity strength, quality of life and movement performance capacity of the respondent

As shown in table 2. The mean strength for the right and left lower extremities were 13.52 ± 5.66 and 13.41 ± 5.69 respectively. The mean score for movement performance capacity was 6.18 ± 2.44.

The mean scores for the WHOQOL domains were 52.37 ± 18.61 for the physical health domain, 55.75 ± 14.36 for the psychological domain, 49.07 ± 20.31 for the social relationships domain and 55.69 ± 16.08 for the environment domain. 65 (38.9%) of the respondents had a moderate physical health QOL, 63 (37.7%) had a moderate psychological QOL, 77 (46.1%) had low QOL in the social relationships domain and 63 (37.7%) had low QOL in the environment domain.

Table 2: Lower extremity strength, quality of life and movement performance capacity of the respondents N=167

	Minimum	Maximum	Mean ± SD
Right lower extremity strength	4	28	13.52 ± 5.66
Left lower extremity strength	3	27	13.41 ±5.69
Movement performance capacity	1	12	6.18 ± 2.44
WHOQOL Domains			
Physical Health	6	94	52.37 ± 18.61
Psychological	25	88	55.75 ± 14.36
Social relationships	0	100	49.07 ± 20.31
Environment	21	94	55.69 ± 16.08
WHOQOL Domains	**Frequency**	**Percentage (%)**	
Physical Health			
Low	63	37.7	
Moderate	65	38.9	
High	39	23.4	
Psychological			
Low	58	34.7	
Moderate	63	37.7	
High	46	27.5	
Social relationships			
Low	77	46.1	
Moderate	52	31.1	
High	38	22.8	
Environment			
Low	63	37.7	
Moderate	56	33.5	
High	48	28.7	

4.1.3 Relationship between lower extremity strength, movement performance capacity and quality of life of the respondents

As shown in table 3. There was a significant positive relationship between right lower extremity strength and movement performance capacity ($\rho < 0.001$). There were significant positive relationships between right lower extremity strength and the domains of the WHOQOL; physical health ($\rho < 0.001$), psychological ($\rho < 0.001$), social relationships ($\rho < 0.001$) and environment ($\rho < 0.001$).

There was a significant positive relationship between left lower extremity strength and movement performance capacity ($\rho < 0.001$). There were significant positive relationships between left lower extremity strength and the domains of the WHOQOL; physical health ($\rho < 0.001$), psychological ($\rho < 0.001$), social relationships ($\rho = 0.001$) and environment ($\rho < 0.001$).

There were positive significant relationships between movement performance capacity and the domains of the WHOQOL; physical health ($\rho < 0.001$), psychological ($\rho < 0.001$), social relationships ($\rho = 0.009$) and environment ($\rho < 0.001$).

Table 3: Correlation between lower extremity strength, quality of life and movement performance capacity

	r	ρ
Right LES * Movement performance capacity$^{\alpha}$	0.761	<0.001
Right LES * Physical Health$^{\beta}$	0.583	<0.001
Right LES * Psychological$^{\beta}$	0.507	<0.001
Right LES * Social relationships$^{\beta}$	0.272	<0.001
Right LES * Environment$^{\beta}$	0.268	<0.001
Left LES * Movement performance capacity$^{\alpha}$	0.774	<0.001
Left LES * Physical Health$^{\beta}$	0.550	<0.001
Left LES * Psychological$^{\beta}$	0.486	<0.001
Left LES * Social relationships$^{\beta}$	0.255	0.001
Left LES * Environment$^{\beta}$	0.268	<0.001
Movement performance capacity * Physical Health$^{\beta}$	0.589	<0.001
Movement performance capacity * Psychological$^{\beta}$	0.445	<0.001
Movement performance capacity * Social relationships$^{\beta}$	0.202	0.009
Movement performance capacity * Environment$^{\beta}$	0.272	<0.001

α = Pearson's correlation

β = Spearman rho correlation

4.1.4 Relationship between clinical data of the respondents and movement performance capacity of the respondents

As shown in table 4. There was a negative significant association between duration of Type 2 DM ($r = -0.412$, $\rho = <0.001$), severity of symptoms ($r = -0.657$, $\rho = <0.001$) and the movement performance capacity of the respondents.

Table 4: Pearson correlation between gender, clinical data and movement performance capacity

	r	ρ
Duration of Type 2 DM * Movement Performance capacity	-0.412	<0.001
Severity of symptoms * Movement Performance capacity	-0.657	<0.001
Gender * Movement Performance capacity	-0.060	0.440

4.1.5 Relationship between gender, clinical data and quality of life of the respondents

As shown in table 5. There was a significant association between gender and the WHOQOL domains of physical health ($\rho = 0.036$), psychological ($\rho = 0.024$) and social relationships ($\rho = 0.009$).

There was significant association between duration of Type 2 DM and the WHOQOL domains of physical health ($\rho < 0.001$), psychological ($\rho = 0.004$) and social relationships ($\rho = 0.009$).

There was also significant association between severity of symptoms and the WHOQOL domains of physical health ($\rho < 0.001$) and psychological ($\rho < 0.001$).

Table 5: Chi square association between sociodemographic variables and quality of life

		Physical Health			χ2	ρ
		Low	Moderate	High		
Gender	Male	25	27	25	2	0.036
	%	32.5%	35.1%	32.5%		
	Female	38	38	14		
	%	42.2%	42.2%	15.6%		
Duration	6 months – 1year	3	10	10	20.945	<0.001
	%	13.0%	43.5%	43.5%		
	1 year – 2 years	11	16	16		
	%	25.6%	37.2%	37.2%		
	> 2 years	49	39	13		
	%	48.5%	38.6%	12.9%		
Severity	Mild	4	9	8	47.374	<0.001
	%	19.0%	42.9%	38.1%		
	Moderate	32	54	31		
	%	27.4%	46.2%	26.5%		
	Severe	27	2	0		
	%	93.1%	6.9%	0.0%		
			Psychological			
Gender	Male	29	21	27	7.424	0.024
	%	37.7%	27.3%	35.1%		
	Female	29	42	19		
	%	32.2%	46.7%	21.1%		
Duration	6 months – 1year	9	5	9	15.264	0.004
	%	39.1%	21.7%	39.1%		
	1 year – 2 years	6	20	17		
	%	14.0%	46.5%	39.5%		
	> 2 years	43	38	20		
	%	42.6%	37.6%	19.8%		
Severity	Mild	5	7	9	28.591	<0.001

	%	23.8%	33.3%	42.9%		
	Moderate	31	50	36		
	%	26.5%	42.7%	30.8%		
	Severe	22	6	1		
	%	75.9%	20.7%	3.4%		
			Social Relationships			
Gender	Male	37	16	24	9.486	0.009
	%	48.1%	20.8%	31.2%		
	Female	40	36	14		
	%	44.4%	40.0%	15.6%		
Duration	6 months – 1year	13	1	9	13.413	0.009
	%	56.5%	4.3%	39.1%		
	1 year – 2 years	14	18	11		
	%	32.6%	41.9%	25.6%		
	> 2 years	50	33	18		
	%	49.5%	32.7%	17.8%		
Severity	Mild	11	4	6	5.996	0.199
	%	52.4%	19.0%	28.6%		
	Moderate	48	42	27		
	%	41.0%	35.9%	23.1%		
	Severe	18	6	5		
	%	62.1%	20.7%	17.2%		
			Environment			
Gender	Male	28	25	24	0.411	0.814
	%	36.4%	32.5%	31.2%		
	Female	35	31	24		
	%	38.9%	34.4%	26.7%		
Duration	6 months – 1year	10	7	6	1.406	0.843
	%	43.5%	30.4%	26.1%		
	1 year – 2 years	14	14	15		
	%	32.6%	32.6%	34.9%		
	> 2 years	39	35	27		
	%	38.6%	34.7%	26.7%		

Severity	Mild	5	10	6	6.954	0.138
	%	23.8%	47.6%	28.6%		
	Moderate	43	36	38		
	%	36.8%	30.8%	32.5%		
	Severe	15	10	4		
	%	51.7%	34.5%	13.8%		

4.2 Hypotheses Testing

Hypothesis 1: There would be no significant relationship between right lower extremity strength and movement performance capacity of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Pearson's moment correlation

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 2: There would be no significant relationship between right lower extremity strength and quality of life of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Spearman rho correlation

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 3: There would be no significant relationship between left lower extremity strength and movement performance capacity of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Pearson's moment correlation

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 4: There would be no significant relationship between left lower extremity strength and quality of life of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Spearman rho correlation

Observed: ρ < 0.05

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 5: There would be no significant relationship between movement performance capacity and quality of life of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Spearman rho correlation

Observed: ρ < 0.05

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 6: There would be no significant relationship between duration of type 2 DM and movement performance capacity of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Pearson's moment correlation

Observed: ρ < 0.05

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 7: There will be no significant relationship between severity of symptoms and movement performance capacity of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Pearson's moment correlation

Observed: ρ < 0.05

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 8: There will be no significant relationship between gender and movement performance capacity of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Pearson's moment correlation

Observed: $\rho > 0.05$

Since the observed ρ value was greater than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED

Hypothesis 9: There would be no significant association between gender and physical health QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 10: There would be no significant association between gender and psychological QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 11: There would be no significant association between gender and social relationships QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 12: There would be no significant association between gender and environment QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho > 0.05$

Since the observed ρ value was greater than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED

Hypothesis 13: There would be no significant association between duration of type 2 DM and physical health QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 14: There would be no significant association between duration of type 2 DM and psychological QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 15: There would be no significant association between duration of type 2 DM and social relationships QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 16: There would be no significant association between duration of type 2 DM and environment QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho > 0.05$

Since the observed ρ value was greater than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED

Hypothesis 17: There would be no significant association between severity of symptoms and physical health QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 18: There would be no significant association between severity of symptoms and psychological QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED

Hypothesis 19: There would be no significant association between severity of symptoms and social relationships QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho > 0.05$

Since the observed ρ value was greater than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED

Hypothesis 20: There would be no significant association between severity of symptoms and environment QOL of older adults with type 2 DM.

Alpha level: 0.05

Test statistic: Chi square

Observed: $\rho < 0.05$

Since the observed ρ value was greater than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The primary aim of this study was to determine the relationship between lower extremity strength, quality of life and movement performance capacity in patients with Type 2 diabetes mellitus (T2DM). The respondents in this study had a reduced mean lower extremity strength on the right lower limb and the left lower limb. Studies have reported reduced lower extremity muscle strengths among adults with different pathologies including diabetes (Ijzerman et al., 2012; Oke et al., 2009; Bullo et al., 2020). Reduction of muscle strength in patients with diabetes may be attributable to the mitochondrial changes associated with T2DM (Sivitz & Yorek, 2010) and also changes in blood capillary which will affect delivery of nutrients and oxygen to the muscles thereby resulting in tissue hypoxia and damage (Nukada, 2014).

The respondents of this study had a movement performance capacity (SPPB) score of 6.18 (± 2.44). This is in agreement with findings of Oke et al., (2013), who observed reduced functional performance capacity among patients with type 2 diabetes in comparison to non-diabetic individuals.

The respondents in the present study also had a moderate quality of life (QOL) in domains of physical health (38.9%) and psychological QOL (37.7%), the prevalence was reduced in the domains of social relationships and environmental QOL 46.1% and 37.7% of the respondents having low social relationships and environment QOL respectively. A study by Nnachi et al., (2023) also reported fair QOL among diabetic patients in Nigeria.

From the present study it was observed that there was a significant positive relationship between the lower extremity muscle strength of T2DM patients and their movement performance capacity as well as their quality of life. These findings are in tandem with findings by Ijzerman et al., (2012), who reported impaired mobility and reduced QOL being associated with reduced lower extremity muscle strength in patients with T2DM. Wu et al., (2020) also reported reduced walking function which was significantly associated with reduced lower extremity muscle strength. Oyewole et al., (2019) reported mild to moderate burden of global disability among patients with T2DM, with disability greater in the domains of mobility, life activity and participation. Reduced muscle strength observed in patients with T2DM would be expected to negatively impact their movement capacity, which would explain the low movement performance capacity observed in this study. Walking and performance of activities of daily living are essential aspects of human life, the impact of reduced muscle strength and movement performance capacity on performance of activities of daily living among patients with T2DM, coupled with psychological toll of lifestyle changes and management of the symptoms and complications can result in reduced QOL among these patients.

Additionally, this present study examined the relationship between clinical factors such as duration and severity of T2DM among the respondents and their movement performance capacity and quality of life. Duration of T2DM and severity of symptoms were observed to be significantly correlated with movement performance capacity. Increase in duration of T2DM and severity of symptoms was observed to be associated with reduction in movement performance capacity. Leenders et al., (2013) reported greater decline in lean lower limb, muscle strength and functional capacity in older adults with T2DM, but not specifically in relation to the duration of T2DM. Increased duration of T2DM result in worsening of complications of T2DM (Liu et al., 2010), which will ultimately result in greater reduction of the muscle strength and functional capacity of T2DM patients.

There was also significant association between duration of T2DM and the physical health, psychological and social relationships domain and between the severity of T2DM and the physical health and psychological domains of WHOQOL. A systematic review by Jing et al., (2018) reported severity and duration of T2DM significantly impact the quality of life of T2DM patients.

5.2 Conclusion

In conclusion, findings from this study showed that patients with type 2 DM had reduced lower extremity strength, poor movement performance capacity and moderate quality of life. There was also a significant relationship between lower extremity strength, quality of life and movement performance capacity.

5.3 Recommendations

Clinicians should be well informed of the impact type 2 diabetes mellitus has on various aspect of a patient's life such as their lower extremity strength, quality of life and movement performance. These clinical features should be properly assessed in all type 2 DM patients and proper management steps should be taken in order to prevent or manage these clinical complications among the elderly.

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APPENDIX 1

INFORMED CONSENT FORM

TITLE OF STUDY: Relationship between lower extremity strength, quality of life and movement performance capacity in patients with type 2 diabetes mellitus.

INVESTIGATOR: EDAWA-DUDU OFEORITSE SALOME

SUPERVISOR: PROF. KAYODE OKE

FINANCIAL SPONSORSHIP: This research project is self-sponsored

PURPOSE OF THE RESEARCH: The purpose of the research is to determine the relationship between lower extremity strength, quality of life and movement performance capacity in patients with type 2 diabetes mellitus.

PROCEDURES TO BE FOLLOWED

I. Attend an initial screening session to determine your eligibility based on specific inclusion and excusion criteria.

II. Complete questionnaire to assess your quality of life

III. Engage in activities to assess your movement performance capacity

IV. A dynamometer will be used to assess your lower extremity strength.

COMPENSATION

There will be no financial compensation for participating in this study.

VOLUNTARY PARTICIPATION

Please note that your participation in this research is entirely voluntary. No form of discrimination will be meted to you, should you decide not to participate in this study. You are entirely free to change your mind and stop participating even if you agreed earlier.

SIDE EFFECTS

There is no anticipated adverse effect associated with participating in this study.

BENEFITS

By participating in this study, you will have the opportunity to contribute to scientific research that aims to determine the relationship between lower extremity strength, quality of life and movement performance capacity in patients with type 2 diabetes mellitus.

CONFIDENTIALITY

All information and data obtained in the course of this study will be treated confidentially. The names of the participants will not be written on the questionnaire, and all information collected will be encoded in a file in my personal computer and passworded. Thereafter the questionnaires will be shelved and locked in my personal document cabinet.

CONTACT INFORMATION

EDAWA-DUDU OFEORITSE SALOME

PROJECT STUDENT.

Email: salomeofe@gmail.com

Tel: 09012490962

Ethics and Research Committee

University of Benin Teaching Hospital

Benin City.

Phone Number: 07063331337

CERTIFICATE OF CONSENT

I have read the above information (or it has been read to me). I had the opportunity to ask questions about it and the questions were answered to my satisfaction.

(A) I consent voluntarily to take part as a participant in this study

(B) I do not consent to participate in this study.

Name of Participant: ---

Signature of participant: ---

Date:---

APPENDIX 2

SOCIODEMOGRAPHIC DATA

Please fill in the details

Gender: ☐ Female ☐ Male

Education Level: ☐ Primary ☐ Secondary ☐ Bsc ☐ Masters ☐ PhD

Marital Status: ☐ Single ☐ Married ☐ Divorced

Religion: ☐ Christian ☐ Muslim ☐ Traditional ☐ Others

Smoking: ☐ Yes ☐ No

Socio-economic Status: ☐ Low ☐ Medium ☐ High

CLINICAL DATA

Co-morbidities: ☐ Yes ☐ No

Complications: ☐ Yes ☐ No

Duration: ☐ 6 months- 1 year ☐ 1 year - 2 years ☐ >2 years

Gycaemic Index: ______________________

Insulin Intake:

Severity: Mild ——|—|—|—|—|—|—|—|—|—|—— Severe

Moderate

APPENDIX 3

Figure 6: Image of the improvised leg dynamometer attached to a wooden chair

APPENDIX 4

WHOQOL-BREF QUESTIONNAIRE

Please read the question, assess your feelings, for the last two weeks, and circle the number on the scale for each question that gives the best answer for you.

		Very poor	Poor	Neither poor nor good	Good	Very good
1	How would you rate your quality of life?	1	2	3	4	5

		Very dissatisfied	Fairly Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
2	How satisfied are you with your health?	1	2	3	4	5

The following questions ask about how much you have experienced certain things in the **last two weeks**.

		Not at all	A Small amount	A Moderate amount	A great deal	An Extreme amount
3	To what extent do you feel that physical pain prevents you from doing what you need to do?	1	2	3	4	5
4	How much do you need any medical treatment to function in your daily life?	1	2	3	4	5
5	How much do you enjoy life?	1	2	3	4	5
6	To what extent do you feel your life to be meaningful?	1	2	3	4	5

		Not at all	Slightly	Moderately	Very	Extremely
7	How well are you able to concentrate?	1	2	3	4	5
8	How safe do you feel in your daily life?	1	2	3	4	5
9	How healthy is your physical environment?	1	2	3	4	5

		Not at all	Slightly	Somewhat	To a great extent	Completely
10	Do you have enough energy for everyday life?	1	2	3	4	5
11	Are you able to accept your bodily appearance?	1	2	3	4	5
12	Have you enough money to meet your needs?	1	2	3	4	5
13	How available to you is the information you need in your daily life?	1	2	3	4	5
14	To what extent do you have the opportunity for leisure activities?	1	2	3	4	5

		Not at all	Slightly	Moderately	Very	Extremely
15	How well are you able to get around physically?	1	2	3	4	5

The following questions ask you to say how good or satisfied you have felt about various aspects of your life over the **<u>last two weeks</u>**.

		Very Dissatisfied	Fairly Dissatisfied	Neither Satified nor Dissatisfied	Satisfied	Very satisfied
16	How satisfied are you with your sleep?	1	2	3	4	5
17	How satisfied are you with your ability to perform your daily living activities?	1	2	3	4	5
18	How satisfied are you with your capacity for work	1	2	3	4	5
19	How satisfied are you with yourself?	1	2	3	4	5
20	How satisfied are you with your personal relationships?	1	2	3	4	5

21	How satisfied are you with your sex life?	1	2	3	4	5
22	How satisfied are you with the support you get from your friends?	1	2	3	4	5
23	How satisfied are you with the conditions of your living place?	1	2	3	4	5
24	How satisfied are you with your access to health services?	1	2	3	4	5
25	How satisfied are you with your transport?	1	2	3	4	5

The following question refers to **how often** you have felt or experienced certain things in the last two weeks.

		Never	Infrequently	Sometimes	Frequently	Always
26	How often do you have negative feelings such as blue mood, despair, anxiety or depression?	1	2	3	4	5

THE END

APPENDIX 5

Study ID ____________________ Date ________________ Tester Initials __________________

SHORT PHYSICAL PERFORMANCE BATTERY PROTOCOL AND SCORE SHEET

All of the tests should be performed in the same order as they are presented in this protocol. Instructions to the participants are shown in bold italic and should be given exactly as they are written in this script.

1. BALANCE TESTS

The participant must be able to stand unassisted without the use of a cane or walker. You may help the participant to get up.

Now let's begin the evaluation. I would now like you to try to move your body in different movements. I will first describe and show each movement to you. Then I'd like you to try to do it. If you cannot do a particular movement, or if you feel it would be unsafe to try to do it, tell me and we'll move on to the next one. Let me emphasize that I do not want you to try to do any exercise that you feel might be unsafe.

Do you have any questions before we begin?

A. Side-by-Side Stand

1. ***Now I will show you the first movement.***
2. (Demonstrate) ***I want you to try to stand with your feet together, side-by-side, for about 10 seconds.***
3. ***You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop.***
4. Stand next to the participant to help him/her into the side-by-side position.
5. Supply just enough support to the participant's arm to prevent loss of balance.
6. When the participant has his/her feet together, ask ***"Are you ready?"***
7. Then let go and begin timing as you say, ***"Ready, begin."***
8. Stop the stopwatch and say ***"Stop"*** after 10 seconds or when the participant steps out of position or grabs your arm.
9. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test.

Study ID ____________________ Date _________________ Tester Initials __________________

B. Semi-Tandem Stand

1. ***Now I will show you the second movement***.

2. (Demonstrate) ***Now I want you to try to stand with the side of the heel of one foot touching the big toe of the other foot for about 10 seconds. You may put either foot in front, whichever is more comfortable for you.***

3. ***You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop.***

4. Stand next to the participant to help him/her into the semi-tandem position

5. Supply just enough support to the participant's arm to prevent loss of balance.

6. When the participant has his/her feet together, ask ***"Are you ready?"***

7. Then let go and begin timing as you say ***"Ready, begin."***

8. Stop the stopwatch and say ***"Stop"*** after 10 seconds or when the participant steps out of position or grabs your arm.

9. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test.

C. Tandem Stand

1. ***Now I will show you the third movement***.

2. (Demonstrate) ***Now I want you to try to stand with the heel of one foot in front of and touching the toes of the other foot for about 10 seconds. You may put either foot in front, whichever is more comfortable for you.***

3. ***You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop.***

4. Stand next to the participant to help him/her into the tandem position.

5. Supply just enough support to the participant's arm to prevent loss of balance.

6. When the participant has his/her feet together, ask ***"Are you ready?"***

7. Then let go and begin timing as you say, ***"Ready, begin."***

8. Stop the stopwatch and say ***"Stop"*** after 10 seconds or when the participant steps out of position or grabs your arm.

Study ID ____________________ Date _________________ Tester Initials __________________

SCORING:

A. Side-by-side-stand

Held for 10 sec ❒ 1 point

Not held for 10 sec ❒ 0 points

Not attempted ❒ 0 points

If 0 points, end Balance Tests

Number of seconds held if less than 10 sec: __.__ __sec

If participant did not attempt test or failed, circle why:	
Tried but unable	1
Participant could not hold position unassisted	2
Not attempted, you felt unsafe	3
Not attempted, participant felt unsafe	4
Participant unable to understand instructions	5
Other (specify) ______________________	6
Participant refused	7

B. Semi-Tandem Stand

Held for 10 sec ❒ 1 point

Not held for 10 sec ❒ 0 points

Not attempted ❒ 0 points *(circle reason above)*

If 0 points, end Balance Tests

Number of seconds held if less than 10 sec: __.__ __sec

C. Tandem Stand

Held for 10 sec ❒ 2 points

Held for 3 to 9.99 sec ❒ 1 point

Held for < than 3 sec ❒ 0 points

Not attempted ❒ 0 points (circle reason above)

Number of seconds held if less than 10 sec: __.__ __sec

D. Total Balance Tests score_________(sum points)

Comments: ____

Study ID ____________________ Date ________________ Tester Initials __________________

2. GAIT SPEED TEST

Now I am going to observe how you normally walk. If you use a cane or other walking aid and you feel you need it to walk a short distance, then you may use it.

A. First Gait Speed Test

1. ***This is our walking course. I want you to walk to the other end of the course at your usual speed, just as if you were walking down the street to go to the store.***

2. Demonstrate the walk for the participant.

3. ***Walk all the way past the other end of the tape before you stop. I will walk with you. Do you feel this would be safe?***

4. Have the participant stand with both feet touching the starting line.

5. ***When I want you to start, I will say: "Ready, begin."*** When the participant acknowledges this instruction say: ***"Ready, begin."***

6. Press the start/stop button to start the stopwatch as the participant begins walking.

7. Walk behind and to the side of the participant.

8. Stop timing when one of the participant's feet is completely across the end line.

B. Second Gait Speed Test

1. ***Now I want you to repeat the walk. Remember to walk at your usual pace, and go all the way past the other end of the course.***

2. Have the participant stand with both feet touching the starting line.

3. ***When I want you to start, I will say: "Ready, begin."*** When the participant acknowledges this instruction say: ***"Ready, begin."***

4. Press the start/stop button to start the stopwatch as the participant begins walking.

5. Walk behind and to the side of the participant.

6. Stop timing when one of the participant's feet is completely across the end line.

Study ID ____________________ Date ________________ Tester Initials __________________

GAIT SPEED TEST SCORING:

Length of walk test course: Four meters ❒ Three meters ❒

A. Time for First Gait Speed Test (sec)

1. Time for 3 or 4 meters __ __.__ __sec
2. If participant did not attempt test or failed, circle why:

Tried but unable	1
Participant could not walk unassisted	2
Not attempted, you felt unsafe	3
Not attempted, participant felt unsafe	4
Participant unable to understand instructions	5
Other (Specify) ____________________	6
Participant refused	7

Complete score sheet and go to chair stand test

3. Aids for first walk...............None ❒ Cane ❒ Other ❒

Comments:____

____

____

B. Time for Second Gait Speed Test (sec)

1. Time for 3 or 4 meters __ __.__ __ sec
2. If participant did not attempt test or failed, circle why:

Tried but unable	1
Participant could not walk unassisted	2
Not attempted, you felt unsafe	3
Not attempted, participant felt unsafe	4
Participant unable to understand instructions	5
Other (Specify)	6
Participant refused	7

3. Aids for second walk............ None ❒ Cane ❒ Other ❒

What is the time for the faster of the two walks?
Record the shorter of the two times __ __.__ __ sec
[If only 1 walk done, record that time] __ __.__ __ sec

If the participant was unable to do the walk: ❒ **0 points**

For 4-Meter Walk:

If time is more than 8.70 sec:	❒ **1 point**
If time is 6.21 to 8.70 sec:	❒ **2 points**
If time is 4.82 to 6.20 sec:	❒ **3 points**
If time is less than 4.82 sec:	❒ **4 points**

For 3-Meter Walk:

If time is more than 6.52 sec:	❒ **1 point**
If time is 4.66 to 6.52 sec:	❒ **2 points**
If time is 3.62 to 4.65 sec:	❒ **3 points**
If time is less than 3.62 sec:	❒ **4 points**

Study ID ____________________ Date __________________ Tester Initials __________________

3. CHAIR STAND TEST

Single Chair Stand

1. ***Let's do the last movement test. Do you think it would be safe for you to try to stand up from a chair without using your arms?***

2. ***The next test measures the strength in your legs.***

3. (Demonstrate and explain the procedure.) ***First, fold your arms across your chest and sit so that your feet are on the floor; then stand up keeping your arms folded across your chest.***

4. ***Please stand up keeping your arms folded across your chest.*** (Record result).

5. If participant cannot rise without using arms, say ***"Okay, try to stand up using your arms."*** This is the end of their test. Record result and go to the scoring page.

Repeated Chair Stands

1. ***Do you think it would be safe for you to try to stand up from a chair five times without using your arms?***

2. (Demonstrate and explain the procedure): ***Please stand up straight as QUICKLY as you can five times, without stopping in between. After standing up each time, sit down and then stand up again. Keep your arms folded across your chest. I'll be timing you with a stopwatch.***

3. When the participant is properly seated, say: ***"Ready? Stand"*** and begin timing.

4. Count out loud as the participant arises each time, up to five times.

5. Stop if participant becomes tired or short of breath during repeated chair stands.

6. Stop the stopwatch when he/she has straightened up completely for the fifth time.

7. Also stop:
   - If participant uses his/her arms
   - After 1 minute, if participant has not completed rises
   - At your discretion, if concerned for participant's safety

8. If the participant stops and appears to be fatigued before completing the five stands, confirm this by asking ***"Can you continue?"***

9. If participant says "Yes," continue timing. If participant says "No," stop and reset the stopwatch.

Study ID ____________________ Date _________________ Tester Initials __________________

SCORING

Single Chair Stand Test

	YES	NO
A. Safe to stand without help	❐	❐

B. Results:

Participant stood without using arms	❐	→ Go to Repeated Chair Stand Test
Participant used arms to stand	❐	→ End test; score as 0 points
Test not completed	❐	→ End test; score as 0 points

C. If participant did not attempt test or failed, circle why:

Tried but unable	1
Participant could not stand unassisted	2
Not attempted, you felt unsafe	3
Not attempted, participant felt unsafe	4
Participant unable to understand instructions	5
Other (Specify) ______________________________	6
Participant refused	7

Repeated Chair Stand Test

	YES	NO
A. Safe to stand five times	❐	❐

B. If five stands done successfully, record time in seconds.

Time to complete five stands __ __.__ __ sec

C. If participant did not attempt test or failed, circle why:

Tried but unable	1
Participant could not stand unassisted	2
Not attempted, you felt unsafe	3
Not attempted, participant felt unsafe	4
Participant unable to understand instructions	5
Other (Specify)	6
Participant refused	7

Scoring the Repeated Chair Test

Participant unable to complete 5 chair stands or completes stands in >60 sec:	❐ 0 points
If chair stand time is 16.70 sec or more:	❐ 1 points
If chair stand time is 13.70 to 16.69 sec:	❐ 2 points
If chair stand time is 11.20 to 13.69 sec:	❐ 3 points
If chair stand time is 11.19 sec or less:	❐ 4 points

Study ID ____________________ Date _________________ Tester Initials ___________________

Scoring for Complete Short Physical Performance Battery

Test Scores

Total Balance Test score	_____	**points**
Gait Speed Test score	_____	**points**
Chair Stand Test score	_____	**points**
Total Score	_____	**points (sum of points above)**

APPENDIX 6

Figure 7: Measurement of lower extremity strength while participant is seated.

APPENDIX 7

UNIVERSITY OF BENIN TEACHING HOSPITAL

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B. Sc, (Hons)FJPMD, Dip. Theo. AHAN

HEALTH RESEARCH ETHICS COMMITTEE APPROVAL

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/148301179

PROPOSAL TITLE: "RELATIONSHIP BETWEEN LEG MUSCLE STRENGTH, QUALITY OF LIFE AND MOVEMENT PERFORMANCE CAPACITY IN PATIENT WITH TYPE 2 DIABETES MELLITUS"

PRINCIPAL INVESTIGATOR(S): EDAWA-DUDU OFEORITSE SALOME

DEPARTMENT/INSTITUTION: DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA

CONSIDERED AUGUST 15TH, 2023

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 15/08/2023 TO 14/08/2024. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI pp SIGNATURE & DATE............16-08-23

SUPERVISOR (S): PROFESSOR KAYODE OKE

DECLARATION BY INVESTIGATOR(S):
PROTOCOL NUMBER (please quote in all enquiries)
Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study. In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of your approval and avoid disruption of your research. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit your research site without previous notification.

Signature & Date..................18/08/23