DIETARY HABITS AND THEIR INFLUENCE ON DIABETIC COMPLICATIONS AMONG TYPE 2 DIABETICS IN MOROGORO MUNICIPALITY

EDINA LEONARD NDAU

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN HUMAN NUTRITION OF SOKOINE UNIVERSITY OF AGRICULTURE.

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ABSTRACT

This study was designed to investigate the dietary habits and their influence on diabetic complications among type 2 diabetics. Purposive and random sampling were used to obtain a sample of 84 diabetic subjects who were already on treatment. Data were analyzed using Predictive Analysis Software (PASW) program version 16.0. Results showed that, 66.7% (n = 56) of the respondents had poor dietary habits, whereby most of the subjects consumed foods with high glycemic index almost daily. Most commonly foods consumed included refined maize "ugali", white breads, chapatti, buns, water-melon, soda, white rice, pineapples and honey. Poor dietary habits among type 2 diabetics were the main reason for complications related to diabetes. The most common diabetic complications reported by the respondents were hypertension, kidney problems, eye problems, foot problems, stroke, nerve problems, vaginal fungus, sexual problems and hypotension. Biomedical measures that were strongly correlated with diabetic complications were body mass index, waist and hip circumferences, body fat mass, blood pressure, and fasting blood glucose. Lifestyle behaviors that were strongly correlated with the diabetic complications were lack of physical exercises and alcohol consumption. Based on this study, the best dietary and lifestyle behaviors that were best predictors for diabetic complications were age, sex, and waist-hip-ratio and vegetables consumption. It was concluded from this study that, poor dietary management practices associated with inappropriate food selection and lack of physical exercises among the respondents were the major factors that influenced diabetic related complications. Therefore, it was recommended based on the findings of this study that, diabetic patients should be educated on the importance of physical exercises and their role in clearing out glucose and insulin resistance. Also, they should be taught on selection of low glycemic index foods (meal patterns) which are available in their localities in order to improve the quality of life and increasing their survival.

DECLARATION

I, Edina Leonard Ndau, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted to any other institution.

Edina Leonard Ndau — 25th NOVEMBER 2013

(MSc Candidate) — Date

The above declaration is confirmed

Prof. T.C.E. Mosha — 25th/11/2013

(Supervisor) — Date

Ms V. Gowele — 25th/11/2013

(Supervisor) — Date

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DEDICATION

To my parents, Ndau Leonard Ndau and Magdalena Mkumbo, who in their love, patience and subtle ways initiated and inspired me to pursue my education.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADA	American Diabetes of Association
AIDS	Acquired Immune Deficiency Syndrome
AMP	Amputation
BFM	Body Fat Mass
BMI	Body Mass Index
BMI	Body Mass Index
BP	Blood Pressure
DBP	Diastolic Blood Pressure
DKA	Diabetic Ketoacidosis
FBG	Fasting Blood Glucose
FFA	Fatty Free Acids
GDM	Gestational Diabetes Mellitus
GI	Glycemic Index
GIP	Gastric Inhibitory Polypeptide
GL	Glycemic Load
GLUT	Glutathione
GSH	Reduced Glutathione
HDL	High Density Lipoprotein
HHS	Hyperosmolar Hyperglycemic State
HIV	Human Immune Deficiency
IDDM	Insulin Dependent Diabetes Mellitus
IDF	International Diabetes Federation
IRS	Insulin Receptor Substrates
KP	Knowledge and Practices

LDL	Low Density Lipoprotein
Max	Maximum
mmHg	Millimeters of Mercury
MUFA	Monounsaturated Fatty Acids
NIDDM	Noninsulin Dependent Diabetes Mellitus
PASW	Predictive Analysis Software
PDK1	Pyruvate Dehydrogenase Kinase, Isozyme 1
PIP2	Phosphatidylinositol Bisphosphate
PIP3	Phosphatidylinositol Trisphosphate
PKB	Protein Kinase B
PUFA	Polyunsaturated Fatty Acids
PVD	Peripheral Vascular Disease
QOL	Quality of Life
RDA	Recommended Daily Allowance
RONS	Reactive Oxygen Nitrogen Species
SBP	Systolic Blood Pressure
SOD	Superoxide Dismutase
TL	Tall
USA	United States of America
WC	Waist Circumference
WHC	Waist-Hip Circumference
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Diabetes mellitus is a metabolic disorder characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism. It is caused by defects in insulin secretion, insulin action, or both (Martin and Michael, 2011; American Diabetes of Association, 2008; Sukha and Rubin, 2007). Chronic hyperglycemia is the hallmark sign of diabetes in diabetic patients (Tucker *et al.*, 2008). It is associated with long-term damage, dysfunction and failure of various organs including the eyes, kidneys, nerves, heart, and blood vessels (American Diabetes of Association, 2012; Mario and Sridevi, 2008).

Diabetes mellitus is classified into four different types (American Diabetes of Association, 2012; American Diabetes of Association, 2011; Mario and Sridevi, 2008). First, is type 1 diabetes or insulin dependent diabetes mellitus (IDDM). This form of diabetes accounts for only 5 to 10% of those with diabetes. Previously, it was called insulin-dependent diabetes or juvenile diabetes because it occurred in children. It results from a cellular-mediated autoimmune destruction of the β-cells of the pancreas. The other form is Type 2 diabetes (non-insulin-dependent diabetes mellitus - (NIDDM) which accounts for approximately 90 to 95% of those with diabetes. It is referred to as non-insulin-dependent diabetes. Type 2 diabetes is an adult-onset diabetes. It is common in individuals who have insulin resistance and usually have relative (rather than absolute) insulin deficiency. Also there is gestational diabetes mellitus (GDM) which is defined as any degree of glucose intolerance with onset or first diagnosed during pregnancy. The fourth type of diabetes is regarded as specific types of diabetes due to other causes. For example, genetic defects in

β-cell function, genetic defects in insulin action, diseases of the exocrine pancreas (such as cystic fibrosis), and drug- or chemical-induced (such as in the treatment of HIV/AIDS or after organ transplantation (American Diabetes of Association, 2012; American Diabetes of Association, 2011; Rajeswari, 2011).

The incidence of type 2 diabetes is increasing rapidly worldwide (National Institutes of Health, 2010; Liu *et al.*, 2010; Dawit *et al.*, 2010; Mitra *et al.*, 2007). Currently, prevalence of type 2 diabetes mellitus among adult population worldwide is 8.3% (Shaw *et al.*, 2011), while sub-Saharan Africa the prevalence is 16% (Diabetes Leadership Forum, 2010). In conjunction with genetic susceptibility, type 2 diabetes is brought about by environmental and behavioral factors, such as sedentary lifestyles and over nutrition with accompanying overweight and obesity (Claude *et al.*, 2010). Currently, the greatest number of people with diabetes worldwide is in the age group of 40 – 59 years (Shaw *et al.*, 2010). This means that the age of onset of type 2 diabetes is decreasing. Previously, the age of onset was above 60 years (Diabetes Leadership Forum, 2010). It has been predicted that, by 2030 there will be less number of people with diabetes in the 60 – 79 year-old age-groups in sub -Saharan Africa (Diabetes Leadership Forum, 2010).

People with type 2 diabetes are at increased risk for multiple and complex complications related to macro-vascular diseases (coronary heart disease, stroke, and peripheral arterial diseases) and micro-vascular diseases (nephropathy, retinopathy, and neuropathy) which are known as chronic complications (American Diabetes of Association, 2010). Acute complications including diabetic ketoacidosis (DKA), hyperosmolar hyperglycemic state (HHS), and hypoglycemia are also associated with type 2 diabetes mellitus (Dawit *et al.*, 2010). Chronic complications are the major outcomes of type 2 diabetes mellitus progress,

which reduce the quality of life of patients, induce heavy burden on the health care system, and increase diabetic mortality (Liu *et al.*, 2010).

Prevalence and incidences of chronic and acute complications in type 2 diabetics can be minimized by using recommended diabetic diets. Treatment aims at relieving symptoms and reducing the risk of long-term complications, which increase linearly with the degree of derangement of the metabolic control (Shaw *et al.*, 2010). Eating a healthy diet in combination with physical exercise helps to control blood glucose and blood lipids, maintain a healthy weight or lose weight in case of overweight or obese and decrease medication use (Stephen, 2009). Healthy diet also helps to minimize complications from high blood glucose such as nerve problems, (neuropathy) kidney problems, (nephropathy), vision problems (retinopathy) and other complications such as heart diseases and circulatory problems (American Diabetes of Association, 2007) and diabetic foot complication caused by neuropathy are also reduced (Tesfaye and Gill, 2011). Therefore, management of type 2 diabetes by diet could drastically reduce the huge medical burden resulting from the complications of the disease.

1.2 Problem Statement and Justification

Type 2 diabetes related complications are the major problems in the management of the disease since they begin early in the disease process and well before clinical diagnosis (Garbe *et al.*, 2008). Improper dietary intake may be an important reason for increased risk of diabetic complication associated with type 2 diabetes (American Diabetes of Association, 2011). It has been reported that, due to improper dietary intake, the prevalence of complications has increased in keeping with the rising occurrence of type 2 diabetes (American Diabetes of Association, 2010; Salas-Salvado *et al.*, 2011).

The cost to care for patients with type 2 diabetes in the U.S. is approximately $132 billion. Of those costs, $40 billion is indirect medical expenses (disability and work loss), and $92 billion dollars is direct medical expenses (those attributable to the disease itself, i.e. micro-vascular and macro-vascular complications). Approximately 25% of the total medicare budget is used for the treatment of type 2 diabetes and its complications. In Africa, the burden of diabetes cost is huge and depends upon the individual and the family. It has been established that, 50% of diabetes care is paid by the patients, 44% by the family, 2% by the employer, 2% by charities and others, while only 2% by the government (Ahmed *et al.*, 2010). Ten years ago, prevalence of Type 2 diabetes in Tanzania was 1%, but now it has increased up to 5.8% (Kolling *et al.*, 2010). This is likely straining the budgets for health of poor families. For example, a recent estimate in Tanzania showed that, treatment of diabetic complications represented 31% of total outpatient costs in one of the main hospitals in Dar es Salaam, with a yearly cost of $138 or 217,363.8 TShs per person (Tesfaye and Gill, 2011). The largest economic burden is the monetary value associated with disability and loss of life as a result of the disease itself and its related complications. The WHO predicted net losses in national income from type 2 diabetic complications to be $2.5million or 3,937.75 TSh. billion in Tanzania, between 2005 and 2015 (International Diabetes Federation, 2011).

Healthy eating is a critical component in the management of type 2 diabetes (Mitra *et al.*, 2007; Collier, 2007). Nutritional health promoting behaviors are thus important strategies to improve the health status of type 2 diabetics. It is not easy for type 2 diabetes patients to change their eating behaviors in order to control their blood glucose levels. A study done by Collier (2007) in USA, showed failures in dietary control among type 2 diabetics. The prevalence of non-adherence for diet ranged from 35 to 75%. Nonetheless, many sub-Saharan countries like Tanzania lack appropriate healthcare education on dietary habits for

diabetic subjects. Lack of healthcare system and education makes many diabetic patients fail to reduce the complication risks due to poor adherence to appropriate diet (Motala *et al.*, 2010).

There is also lack of adequate policies or guidelines and programs aimed at addressing the influence of dietary habits on people affected by diabetes as well as lack of local capacity to conceptualize and implement dietary interventions and diabetes. Non adherence with dietary habits has serious consequences for progression of complications which are the major cause of mortality (Salas-Salvado *et al.*, 2011). Development of tools and models for diabetes health-care could potentially result in a substantial decrease in diabetes with associated vascular complications (Ahmed *et al.*, 2010). This study has been designed to assess dietary habits on their influence on diabetic complications among type 2 diabetic patients. The information will be useful in advising relevant stakeholders on the importance of diet, education and counseling to type 2 diabetes patients. It will also assist planners and health-care providers in planning appropriate programs and interventions aimed at reducing the risk of complications among type 2 diabetics. The study will provide the basis for proposing actions to improve the quality of life and increasing survival of type 2 diabetes mellitus patients.

1.3 Objectives

1.3.1 General objective

To assess dietary habits and their influence on diabetic complications among type 2 diabetics

1.3.2 Specific objectives

(i) To assess the meal patterns of individuals with type 2 diabetes mellitus

(ii) To identify biological risks of diabetic complications among type 2 diabetic patients

(iii) To investigate the knowledge attitude and practices to reduce the risks of complications among type 2 diabetics about diabetes

(iv) To identify the types of diabetic complications common among type 2 diabetics in the study area

1.4 Hypothesis

The following null and alternative hypotheses were tested during the study:-

1.4.1 Null hypothesis

Ho: There is no influence of dietary habits on diabetic complications among type 2 diabetics

1.4.2 Alternative hypothesis

Hi: There is an influence of dietary habits on diabetic complications among type 2 diabetics

1.5 Conceptual Framework

The conceptual framework presents existing relationship between variables that will be used in the study. The conceptual framework binds facts together and provides guidance towards collection of appropriate data or information (Katani, 1999). The framework focused on the association of meal pattern, biological risks and socio- economic and demographic factors to influence diabetic complications.

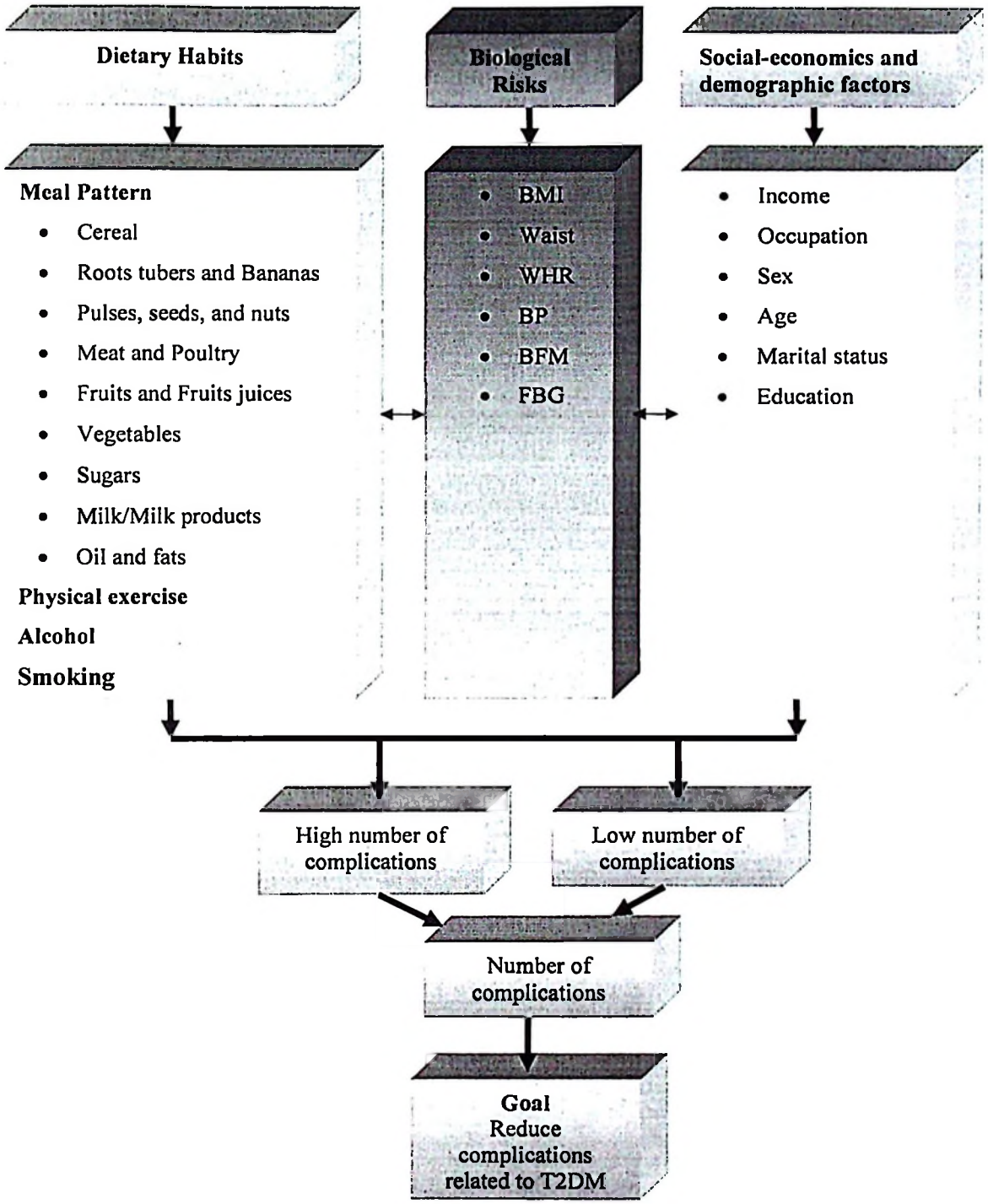

Figure 1: Conceptual framework of the association of meal pattern, biological risks and social demographic factors influencing diabetic complications

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition

Type 2 diabetes mellitus is a metabolic disorder which can be inherited or acquired due to shortage in production of the insulin hormone by the pancreas or by ineffectiveness of insulin hormone produced. Type 2 diabetes was known as adult onset diabetes however, due to decreasing in age of which diabetes is diagnosed, this term is no longer appropriate. There has been a drastic increase in incidence of type 2 diabetes among adolescents accompanying the national rise in adolescent obesity (Das and Pande, 2013). In 2011 there were 366 million people living with diabetes in the world. This is expected to rise to 552 million by 2030 (Shaw *et al.*, 2011). Type 2 diabetic mellitus is the most leading cause of morbidity and mortality worldwide and is responsible for almost 4.6 million deaths annually. US$ 465 billion is spent on care for diabetes (International Diabetes Federation, 2011). Statistically, 90 to 95% of the world population has type 2 diabetes mellitus (Rajeswari *et al.*, 2011; Levitt, 2008).

2.2 Type 2 Diabetes and Insulin Resistance

Impaired insulin action and impaired pancreatic insulin secretion are the principal pathophysiological irregularities leading to increased blood glucose levels. Insulin resistance is a common pathologic state in which target cells fail to respond to the physiological effects of insulin occurring in peripheral organs and leading to irregularities in glucose, lipid and protein metabolism. When the target tissue does not respond to high levels of glucose, glucose builds up in the blood resulting in high blood glucose. In response to raised blood glucose concentration due to insulin resistance, pancreatic β-cells need to increase the insulin secretion to maintain homeostasis in glucose levels however β-

cells become unresponsive to glucose due to pancreatic β-cells dysfunction and eventually type 2 diabetes develops. The etiology of the β-cell dysfunction in diabetics results from both genetic and acquired factors (Ahmed *et al.*, 2010).

2.3 Complications of Type 2 Diabetes Mellitus

The complications of type 2 diabetes are classified as acute (short-term) and chronic (long-term). Acute complications include, diabetic hyperglycemic, hyperosmolar coma and diabetic ketoacidosis, whereas chronic complications include, cardiovascular diseases (hypertension, angina, chronic heart failure, myocardial infarction, other related heart diseases, and peripheral vascular disease conditions), cerebrovascular conditions, nephropathy (micro-albuminuria, renal hypo function, and renal failure), ocular lesions (retinopathy, cataract and blindness), neuropathy, and diabetic foot problems (Rajeswari *et al.*, 2011). These complications may be stratified into macro-vascular complications (all cardiovascular, cerebrovascular and foot diseases) and micro-vascular complications (nephropathies, neuropathy and eye lesions (Tesfaye and Gill, 2011). Micro-vascular complications are known as small blood vessel complications while macro-vascular are known as large blood vessel complications (Anderson, 2008).

2.3.1 Small blood vessel complications

Small blood vessel complications cause damages in small blood vessels the capillaries. Capillaries are tiny blood vessels that carry oxygen and nutrients to all the cells in the body (Anderson, 2012). These complications include changes in the small blood vessels of the eye that result in diabetic retinopathy, in the peripheral nerves, causing neuropathy, and lastly in the kidney, causing diabetic nephropathy (Anderson, 2008; Ahmed *et al.*,

2010). As these small blood vessels get destroyed it leads to blindness, end-stage renal disease and limb amputation (Ahmed *et al.*, 2010).

2.3.1.1 Retinopathy

Diabetic retinopathy is the damage of blood vessels to the retina (back of the eye). The damage of blood vessels to the retinal cause them to leak or become blocked which prevents them from carrying as much oxygen to the retina as they did before the damage. Diabetic retinopathy is the most common cause of acquired blindness in the world. Diabetic retinopathy results in formation of micro-aneurysms (minimal retinopathy), hemorrhages and increased leakage, causing retinal edema and lipid exudates (background retinopathy). When pathological development of new vessels in the retina or abnormal blood vessels and fibrous tissue (i.e. neovascularization) occurs, the retinal path tends to proliferate. Further formation of fibrous tissue may eventually cause retinal detachment and severe visual impairment. The etiology of retinopathy includes hyperglycemia associated biochemical, anatomical, and functional changes (Ahmed *et al.*, 2010).

Retinopathy exists in four stages. First, mild non-proliferative retinopathy. At this stage micro-aneurysms occur. Micro-aneurysms are the areas of balloon-like swelling of the retinal blood vessels. Second stage, moderate non-proliferative retinopathy. At this stage retinal blood vessels become blocked. Third stage, severe non-proliferative retinopathy. This is the stage when the retina becomes deprived of oxygen due to blocked blood supply. Lack of oxygen causes the retina to grow new blood vessels. Fourth stage, proliferative retinopathy. The new blood vessels are abnormal and fragile and grow along the retina and the vitreous gel that fills the inside of the eye. If the blood vessels do not break and bleed, no vision loss or symptoms will occur. However, if they bleed, severe vision loss or blindness may occur. Controlling blood sugar and blood pressure is the most

important way to prevent diabetes from causing retinopathy (Anderson, 2008). The prevalence of retinopathy in Africa is 16 – 55% of people with diabetes. Duration of diabetes and glycaemic control are the major determinants of retinopathy. Other variations are ethnic origins which can be linked primarily to unfavorable social and economic conditions that worsen the risk of poor blood glucose control (Tesfaye and Gill, 2011).

2.3.1.2 Nephropathy

Diabetic nephropathy is the kidney disease that occurs as result of diabetes. Nephropathy is the leading cause of chronic renal failure worldwide. It is responsible for renal failure in about one third of patients who undergo dialysis (Yadav *et al.*, 2008). Diabetic nephropathy is the leading cause of end-stage renal disease in diabetic individuals. Microalbuminuria is the initial markers of this condition which indicates an increased risk of progression to nephropathy as well as an elevated risk of cardiovascular events. In diabetes, high levels of blood glucose can damage the kidneys' filters. This leaves type 2 diabetic people at risk of developing renal impairment. When the kidneys are damaged, the protein albumin leaks out of the kidneys into the urine. This is one of the first signs or early stage renal disease. Diabetic nephropathy, a complication of diabetes, is a chronic and progressive disease of the kidneys which occurs in about one third of all people with diabetes. It is associated with an increased risk of other diabetic complications including a greater risk of cardiovascular disease and lower than average life expectancy (Fowler, 2008).

2.3.1.3 Neuropathy

Nerve disease is known as neuropathy. Diabetic neuropathy affects both sensory and autonomic nerves (Ahmed *et al.*, 2010). The nerves which are responsible for feeling temperature, pressure and pain are called peripheral nerves and which are responsible for

the automatic function of the body such as blood pressure regulation, bladder emptying and digestion are called autonomic nerves (Anderson, 2008). Diabetic neuropathy is encountered in about half of all people with diabetes either as a polyneuropathy or mononeuropathy especially in patients over 60 years old. Around 10% of these cases of neuropathy are associated with abnormal sensations and pain. The incidence of neuropathy increases with duration of diabetes and is accelerated by poor control. Additionally, the death rate is as high as 50% at three years after diagnosis of overt autonomic neuropathy extensive vascular damage. Both of these conditions are life threatening and may result in an altered mental state, loss of consciousness, and possibly death; therefore prompt medical attention is necessary to avoid adverse outcomes (Ahmed *et al.*, 2010).

(a) Peripheral neuropathy

Peripheral neuropathy is common in the feet which causes numbness, burning pain, shooting pain, and tingling. Numbness in the feet can result in a sore or an injury that is not felt. Its symptoms may improve with improved blood sugar control (Fowler, 2008). The rate of peripheral neuropathy in Tanzania is 4 to 84% (Tesfaye and Gill, 2011).

(b) Foot ulceration

Foot complications are the results of infection in the neuropathic foot. Diabetic foot ulcers develop mainly because of the abnormal distribution of pressure. Foot ulcer is one of the most common complications of diabetes in the lower extremity. Diabetic patients are victims of amputation caused by the complications of neuropathy and infection. Prevalence of neuroischaemic lesions in diabetes patients in Tanzania is 17% (Tesfaye and Gill, 2011). Factors which greatly increase the risk of ulceration and amputation as well as the traditional risk factors of neuropathy and PVD are poverty and barefoot walking, inappropriate footwear, poor foot hygiene and delay in seeking medical attention. With the

establishment of foot clinics, major amputations can generally be reduced through regular foot inspection and making an effort not to walk barefoot for the prevention of foot problems. Prevention of peripheral neuropathy through glycaemic control is the most important preventive measure for lower limb ulceration or infection. Diabetic patients in Tanzania show mortality rates of over 50% among patients with severe foot ulcers (Tesfaye and Gill, 2011).

(c) Chronic sensorimotor distal symmetric polyneuropathy

Chronic sensorimotor distal symmetric polyneuropathy is the most common form of neuropathy in diabetics. Patients experience burning, tingling, and electrical pain, but simple numbness. Patients with simple numbness can present with painless foot ulceration. Patients also experience loss of ankle reflex. Patients who have lost 10g monofilament sensation are at considerably elevated risk for developing foot ulceration. Pure sensory neuropathy is relatively rare and is associated with periods of poor glycemic control or considerable fluctuation in diabetes control. It is characterized by isolated sensory findings without signs of motor neuropathy. Symptoms are most prominent at night. Mononeuropathies are more sudden onset and involve virtually any nerve, but the mostly affected nerves are the median, ulnar, and radial. Diabetic amyotrophy may be a manifestation of diabetic mononeuropathy and it is associated with severe pain and muscle weakness and atrophy, usually in large thigh muscles (Fowler, 2008).

(d) Autonomic neuropathy

Autonomic neuropathy is nerve damage of the autonomic functioning of the body parts. Diabetic autonomic neuropathy results into significant morbidity and even mortality in patients with diabetes. Neurological dysfunction may occur in different organ systems and causes gastroparesis (impaired gastric emptying), constipation, diarrhea, orthostatic

hypotension, bladder dysfunction (delayed/incomplete bladder emptying), erectile dysfunction and retrograde ejaculation in males, reduced vaginal lubrication with arousal in women, loss of cardiac pain, resting tachycardia, silent ischemia or infarction, and even sudden cardiac death. Cardiovascular autonomic dysfunction is associated with increased risk of silent myocardial ischemia and mortality (Fowler, 2008).

2.3.2 Large blood vessel problems associated with diabetes

Macro-vascular disease or large blood vessel problems have the central pathological mechanism in process of atherosclerosis, which leads to narrowing of arterial walls throughout the body. Atherosclerosis results from chronic inflammation and injury to the arterial wall in the peripheral or coronary vascular system. In response to endothelial injury and inflammation, oxidized lipids from LDL particles accumulate in the endothelial wall of arteries. The angiotensin II factor promotes the oxidation of such particles. Then, the monocytes infiltrate the arterial wall and differentiate into macrophages, which accumulate oxidized lipids to form foam cells. Once formed, foam cells stimulate macrophage proliferation and attraction of T-lymphocytes. T-lymphocytes, in turn, induce smooth muscle proliferation in the arterial walls and collagen accumulation (Fowler, 2008). Large blood vessel diseases include coronary artery disease, cerebral vascular disease and peripheral vascular disease. Macro-vascular diseases are associated with hardening of the arteries. The heart must work harder to pump blood. This can lead to heart attacks, strokes, high blood pressure and poor blood flow to the arms, legs and head (Anderson, 2008).

2.3.2.1 Coronary artery disease

Coronary artery disease is the hardenings of the arteries that supply the heart muscle with blood. It is the major cause of morbidity and mortality affecting people with diabetes

through angiography and myocardia scintography and ischemic heart disease. Angina causes pain or discomfort the chest, shoulders, arms, jaw, or back, especially during exercise. People with angina have an increased chance of having a heart attack and this occurs when the heart muscle does not receive enough blood and part of the heart muscle is damaged (Anderson, 2008).

The mechanism in which diabetes leads to CVD is through oxidative stress. Oxidative stress occurs within the cellular system when the production of pro-oxidants (free radicals) exceeds the anti-oxidant capacity of the system. The radicals themselves and non-radical species created via interaction with radicals are both known as reactive oxygen-nitrogen species (RONS). Under normal physiological conditions, there is a critical balance between RONS generation and their subsequent ameliorization via the antioxidant defense system. Thus, the impairment of this oxidant/ antioxidant equilibrium in favor of increased RONS is known as oxidative stress. In fact, when RONS are present in excess (RONS>antioxidant defenses), the potential for oxidative damage and disease exists. These oxidized biomolecules can accumulate in bodily tissue and are measured as indirect indices of the oxidative burden. These common molecular products include stable metabolites (e.g. nitrate/nitrite), and/or concentrations of oxidation target products, including lipid peroxidation end products and oxidized proteins and nucleic acids. The extent of oxidative stress can also be estimated by measuring alterations in various parameters of the antioxidant defense system (e.g. enzymatic and non-enzymatic antioxidants). Conditions that promote an increase in RONS production, results into acute state of oxidative stress, which includes those formed during the performance of acute exercise (both aerobic and anaerobic, as well as the consumption of certain macronutrients) (Turker *et al.*, 2008; Ahmed *et al.*, 2010).

2.3.2.2 Cerebral vascular disease

Cerebral vascular disease includes all disorders in which an area of the brain is transiently or permanently affected by ischemia (lack of blood flow) or bleeding. Brain tissue can die from the lack of oxygen if a person develops a blockage in the vessels carrying blood to the brain or the vessels bleed. When brain tissue dies, the person would have a stroke. Stroke that is caused by bleeding is called a hemorrhagic stroke while the stroke caused by a blockage is called an ischemic stroke. Stroke is characterized by sudden weakness or numbness of the face, arm, or leg on one side of the body sudden confusion, trouble talking, or trouble understanding, sudden dizziness, loss of balance, or trouble walking, sudden trouble seeing out of one or both eyes or sudden double vision and sudden severe headache (Anderson, 2008).

Epidemiological data on cerebrovascular disease in Africa have been scarce because of the low proportion of patients presenting to hospitals, the high mortality rate, and inaccuracies and deficiencies in death certification. In Tanzania, regular censuses of three surveillance populations consisting of 307,820 people (125,932 aged below 15 years and 181,888 aged 15 or more) were undertaken with prospective monitoring of all deaths arising in these populations between 1992 and 1995. During the 3-year observation period 11 975 deaths were recorded in the three areas, of which 7629 (64%) were in adults (54% of these in men and 46% in women). In these adults, 5.5% of the deaths were attributed to cerebrovascular disease, 53% of these in men and 47% in women (Tesfaye and Gill, 2011).

2.3.2.3 Peripheral vascular disease

Peripheral vascular disease is a group of diseases of blood vessels outside the heart and brain. It is a narrowing of vessels that carry blood to the legs, arms, stomach or kidneys.

Artery disease occurs when fatty deposits build up in the inner linings of the artery walls. These blockages restrict blood circulation to the kidneys, stomach, arms, legs and feet. In its early stages a common symptom is cramping or fatigue in the legs and buttocks during activity that goes away with rest. This is known as intermittent claudication. People with peripheral artery disease have a higher risk of death from heart attack and stroke (Anderson, 2008). In Tanzania prevalence of peripheral vascular disease is 3 – 79% (Tesfaye, and Gill, 2011).

2.3.2.4 Depression

Depression is twice as much common in people with diabetes as in the general population. It is present in at least 15% of patients with diabetes. Depression is associated with poorer glycemic control, health complications, decreased quality of life and increased healthcare costs (Yadav *et al.*, 2008).

2.3.2.5 Sexual problems

Erectile problems occur in up to 50% of men with diabetes. Men with diabetes may suffer from erectile dysfunction acutely, during periods of high blood glucose or chronically. The prevalence in men over 40 years old with diabetes is high 50%. Failure to achieve erection may be due to psychological causes, macro-vascular disease or pelvic autonomic neuropathy (Fatemi and Taghavi, 2009). Also erectile dysfunction is a side effect of many drugs commonly prescribed to men with diabetes, such as antihypertensive (beta-blockers and thiazide diuretics) and antidepressants (Yadav *et al.*, 2008). Psychogenic erectile dysfunction requires counseling and behavioral therapy. Phosphodiesterase inhibitors (sildenafil – Viagra; tadalafil – Cialis; vardenafil – Levitra) are effective for men with erectile dysfunction where he and his partner wish to resume sexual activity (Fatemi and Taghavi, 2009). In case of women with diabetes some of them complain of impairment in

vaginal lubrication with arousal, presumably due to pelvic autonomic neuropathy (Fatemi and Taghavi, 2009).

2.4 Biological Risks for Development of Diabetes Complications

The most common risk factors to develop complications are long duration of diabetes, hypertension, glycemic control, smoking, obesity (high BMI) and dyslipidemia/ blood lipids (Yadav *et al.*, 2008; Fernandez, 2011). Also, gender is a risk factor for Type 2 diabetes mellitus (Liu *et al.*, 2010).

2.4.1 Hypertension

The presence of hypertension to the people with diabetes is an independent contributory risk factor for coronary heart disease, cerebral vascular disease, peripheral, retinopathy and nephropathy. In order to reduce hypertension as a risk factor to develop complications to a diabetic patient, should target a blood pressure of $\leq$ 130/80mm Hg. Self-monitoring by patients can provide useful information on blood pressure profiles over the 24-hour period (Yadav *et al.*, 2008). The inadequate control of hypertension to patients with type 2 diabetes mellitus is associated complications and co-morbidities (Campbell *et al.*, 2011).

2.4.2 Poor glycemic control

Control of blood glucose is vital in diabetic patients to reduce the incidence of micro-vascular complications and macro-vascular complications (ADA 2013). This can be achieved with mean plasma glucose of 8.3 – 8.9 mmol/L (150–160 mg/dL). Ideally, fasting and pre-prandial glucose should be maintained at, 7 mmol/L (130 mg/dL) and the postprandial glucose at 10 mmol/L (180 mg/dL). 6.0– 6.5 mmo/L might be considered in selected patients (with short disease duration, long life expectancy, no significant CVD)

only if can be achieved without significant hypoglycemia or other adverse effects of treatment. It is important to individualize treatment targets. The desires and values of the patient should be considered, since the achievement of any degree of glucose control requires active participation and commitment (Inzucchi *et al.*, 2012). There are several factors which contribute to poor glycemic control. These include inappropriate food intake, inappropriate insulin or oral hypoglycemic usage, irregular metabolic demand, e.g. exercise, and shift work, inter-current infection (especially urinary tract infection), incorrect administration of medication/insulin and psychological stress (Adham et *al.*, 2010).

2.4.3 Smoking

Among the lifestyle related factors, smoking makes the largest contribution to the absolute risk of macro-vascular complications for people with diabetes. There is evidence that minimal interventions in the general practice setting can improve cessation rates. The diagnosis of diabetes is often a crisis for people and offers an opportunity to bring about cessation of smoking (Yadav *et al.*, 2008).

2.4.4 Obesity

Obesity is an ubiquitous with metabolic dysfunction. It is associated with increased risk of developing insulin resistance. It has been shown that, 60 – 90% of all people with type 2 diabetics mellitus are obese (Yates *et al.*, 2009). Central obesity or increased waist circumference is a key determinant in the development of metabolic syndrome. For males, waist circumference of $\leq$ 94 cm is ideal, waist circumference of 94 – 102 cm is high and waist circumference of $\geq$ 102 cm is very high. For females, waist circumference of $\leq$ 80 cm is ideal, waist circumference of 80 – 88 cm is high and $\geq$ 88 cm is very high (WHO, 2008). Abdominal obesity is determined by accumulation of both subcutaneous and

visceral adipose tissue. It plays a major role in the metabolic irregularities. Insulin resistance and many of its related features could arise from trunk fat delivering free fatty acids (FFA) at a high rate to the liver via the portal vein. This effect in turn increases hepatic glucose production, reduces hepatic insulin clearance, and finally leads to insulin resistance, hence hyperglycemia. Obesity also is associated with hyperglycemia (Fernandez, 2011). In case of body mass index having the BMI of < 18.5 is defined as underweight, BMI of 18.5-24.5 is normal BMI of 25 - 29.9 is overweight, BMI of 30 - 39.9 is obese and BMI over 40 is extremely obese (WHO, 2008). Loss of body weight often results in near normal glycaemic, blood pressure and lipid profiles. Weight loss of 5 to 20% will improve glycaemic control hence reduce obesity and overweight in diabetic individuals and its complications (Dyson *et al.*, 2011).

2.4.5 Dyslipidemia

Dyslipidaemia is common in patients with diabetes and is an independent risk factor for the macro-vascular complications in diabetic people. Often poor glycemic control with persistent hyperglycemia results in hyper-triglyceridaemia. The triglyceride level often drops to acceptable levels when adequate control of weight, diet and glycaemia is achieved (Adham *et al.*, 2010).

2.5 Role of Dietary Habits in Enhancing Type 2 Diabetes Mellitus

Dietary management is the cornerstone of treatment for Type 2 diabetes. Its management aims to achieve improved glycemic control, achieve and maintain reasonable body weight, prevent complications and obtain optimal overall health and wellbeing. Also it addresses individual nutritional needs, considering the personal and cultural preferences and lifestyles. Diabetic patients should consume food in moderate amount; eat variety of foods

regularly at the same time. The appropriate distribution of carbohydrate, fat, and protein is also important, such as 10 to 20% protein, 30% fat and 50 to 60% carbohydrate (Stephen, 2009). In addition, the importance of consuming foods rich fiber and low glycemic index food is important to achieve the normal blood glucose level. Healthy dietary habits is the basis for the treatment of type 2 diabetes and it contributes positively to the maintenance of blood glucose to within the normal range and minimizes the complications of the disease (Polikandrioti and Dokoutsidou, 2009).

2.5.1 The role of carbohydrate

Rising of blood glucose in the body depends on quality of carbohydrate ingested. Carbohydrate ingested, influence the gastrointestinal transit and the velocity of nutrient absorption, and the long-term risk of diabetes. Fiber, wholegrain seeds, glycemic index (GI), and simple sugars in beverages are the crucial qualitative features of dietary carbohydrate relevant to diabetes (Salas-Salvado *et al.*, 2011).

2.5.1.1 Dietary fiber

Dietary fibres are carbohydrate foods that are resistant to digestion by human digestive enzyme. Its intake reduces risk of obesity and diabetes hence provides health lifestyle. There are two types of fibers namely soluble and insoluble fibbers. The soluble viscous fiber plays a crucial role in controlling postprandial glycemic and insulin responses and satiety. This is attributed to its effect of slowing gastric emptying and intestinal nutrient absorption however the insoluble fiber on the other hand is associated with wholegrain foods, which have a unique composition. The uniqueness is due to the fact that the germ and the skin of all seeds (cereals, legumes, and nuts) contain many bioactive phytochemicals with potential health benefits. Wholegrain foods have therefore a beneficial effect on insulin sensitivity in obese subjects, or glucose control in diabetic

patients. The mechanism in which wholegrain foods increase gastric inhibitory polypeptide (GIP), anti-inflammatory effects and changes of the gut microbiota is because of increment in insulin sensitivity (Anderson *et al.*, 2009).

2.5.1.2 Glycemic index (GI)

Glycemic index (GI) is the measure of how a food containing carbohydrate raises the blood glucose when ingested. It indicates the ability of the food to spike the glucose level in the blood when the food is consumed. Glycemic load (GL) is a measure of carbohydrates content per serving. GI and GL are linked with increased risk of diabetes, however, diets high in starch and low in fiber are also associated with increased diabetes risks. Diets with low glycemic index can be associated with improvements of glycemic control, insulin sensitivity, and other intermediate biomarkers (Salas-Salvado *et al.*, 2011). According to Kirpitch and Maryniuk (2011) and Jeya *et al.*, 2011) low GI foods range from 0 – 55 g, moderate GI foods 56 – 69 g and high GI foods ≥70 g.

Table 1: Glycemic index (GI) for various foods

Glycemic Index (g)	Glycemic status	Food item
0-55	Low	Potato chips, Cassava, Banana/plantains, beans, nuts, peas, lentils, meat, eggs, chickens, fish, avocado cucumber, oranges, grapes, apples, mangoes dry apricots, carrots, amaranth, tomatoes, spinach, cabbage, okra, eggplant, milk, (fresh milk) yogurt, coconut milk
56-69	Medium	Macaroni or spaghetti boiled/fried brown rice, ripe bananas, pawpaw
≥70	High	White bread (wheat), donut, refined maize ugali, millet ugali, chapatti, boiled/fried white rice sweet potatoes, boiled watermelon, pineapples, honey, beer, soda, unrefined maize ugali

Source: Kirpitch and Maryniuk (2011); Jeya *et al.*, 2011)

2.5.1.3 Commercial beverages

These beverages contain simple sugars, such as artificially sweetened beverages (soft drinks, non-diet colas, sodas) and natural or commercial fruit juices, which are sugar-enriched. These beverages are prototypes of high GI foods that must not be consumed in significant amounts. High consumption of sugared drinks or fruit juices frequently promotes insulin resistance due to induction of weight gain due to their high energy content (Salas-Salvado *et al.*, 2011).

2.5.2 The role of fat

Dietary fat is important to ensure the optimum quantity and quality of fat in the total diet (Mitra *et al.*, 2007).

2.5.2.1 Importance of fat quantity

Quantity of fat is very important because it is the most energy-dense nutrient. High fat intakes may promote insulin resistance since the amount of fat in a meal results in significant elevations in plasma triglycerides which is the hallmark of postprandial lipidemia. High intakes of total fat and saturated fatty acids also promote cholesterol synthesis, and raise serum very low density lipoprotein (VLDL) and LDL cholesterol, which increase the risk of arteriosclerosis and thrombosis. Improved glycemic control with low fat diets is crucial to diabetic patients for insulin responses (Salas-Salvado *et al.*, 2011).

2.5.2.2 Importance of fat quality

Quality of fat is important for diabetes prevention or glycemic control. For example PUFA as derived from food biomarker is more consistently related to improved glycemic control and/or a reduced risk of diabetes. The linoleic acid (n-6 PUFA) content of adipose

tissue, a good biomarker of intake is also positively associated with insulin sensitivity. While total and n-6 PUFA appear to be protective, long chain n-3 PUFA from marine origin is not. The cooking methods (frying, the type and amount of cooking fat used) also can impair pancreatic B-cell function and insulin secretion. High dietary MUFA intake in the form of olive oil has a significant inverse association with the serum phospholipid proportions and insulin resistance (Salas-Mitra *et al.*, 2007).

2.5.3 Protein

People with diabetes have more need for protein than the general public. The American Diabetes Association nutrition guidelines suggest eating between 15 and 20% of calories as protein. The Recommended Daily Allowance (RDA) for protein is 0.8 grams per kilogram of body weight or 12 - 15% of total daily calorie intake (Stephen, 2009). Animal protein foods such as meats, whole milk dairy foods, and high-fat cheeses should be reduced while protein from plants should be taken in high amount since they have the desirable features of being high-fiber, wholegrain, and low GI foods, e.g. dietary pulses (dried leguminous seeds, including chickpeas, beans, peas and lentils). Animal protein contains all the amino acids our bodies need to function properly and is called complete protein. Protein from plants does not provide all the amino acids we need in one food. However, the mixture of amino acids from cereal and grains (rice, oat, wheat, corn) plus the amino acids contained in starchy legumes (beans, soy beans, chickpeas, dry peas, lentils) provides our body with complete protein (Salas-Salvado *et al.*, 2011).

2.5.4 Minerals

Different minerals play different roles in the body. For example manganese, zinc, molybdenum, selenium and chromium play a crucial role in diabetics in lowering heart diseases. Chromium is also important to maintain normal blood sugar levels. Also

calcium and magnesium and trace elements are beneficial to lower cholesterol and triglyceride levels (Mitra *et al.*, 2007).

2.5.5 Beverages

High intake of beverages such as coffee and cola elevate serum cholesterol levels. Caffeine containing beverage should be restricted since it may aggravate irregular heartbeats. Daily intake of caffeine should not exceed 100 mg/day (Mitra *et al.*, 2009).

2.5.6 Antioxidants

Antioxidants such as vitamin C, vitamin E, zinc, superoxide dismutase (SOD) and reduced glutathione (GSH) plays a great role in delaying high risks of developing certain complications. Deficiency in zinc increases urinary zinc excretion rates (Turker *et al.*, 2008). Also, antioxidants prevent oxidation of LDL to attract monocytes and to further formation of artherosclerotic plaques. Dietary intake of antioxidants including flavanoids naturally present in vegetables and fruits decrease coronary heart diseases and diabetes (Mitra *et al.*, 2007).

2.5.7 Carbohydrate

Ideally carbohydrate should comprise 55 - 60% of the calories, with the form and amount to be determined by individual eating patterns and blood glucose and lipid responses. Refined carbohydrates should be substituted for unrefined carbohydrates to the extent possible, modest amounts of sugars may be acceptable as long as glycemic control and desirable body weight are maintained (Stephen, 2009).

2.5.8 Fat/cholesterol

Should comprise 30% of total calories, and all components should be reduced proportionately. Replacement of saturated with polyunsaturated fat is desirable to reduce cardiovascular risk. Cholesterol should be restricted to 300 mg/day to reduce cardiovascular risk (Mitra *et al.*, 2009).

2.5.9 Alternative sweeteners

Sweeteners are classified into two groups. These include caloric (nutritive) and non-caloric (nonnutritive). In the management of diabetes, nutritive and non-nutritive sweeteners are acceptable especially when used in moderation (Stephen, 2009). Nutritive sweeteners are not calorie-free and may have great effects on blood glucose levels than non-nutritive sweeteners. Nutritive sweeternes are sugars like fructose, dextrose, lactose, maltose, honey, corn syrup and sugar alcohols, including sorbitol, mannitol, xylitol, maltitol and erythritol (Caruana, 2007). Non-nutritive sweeteners are essentially kilojoule-free and therefore have no effect on blood glucose levels. The non-nutritive sweeteners are grouped into synthetic and semi-synthetic compounds that include acesulfame, aspartame, cyclamate, neotame, saccharin and sucralose (Myers, 2011).

2.5.10 Sodium

Sodium should be restricted to 100 mg/1000 kcal, not to exceed 3000 mg/day, to minimize symptoms of hypertension. Severe sodium restriction may, however, be harmful for persons whose diabetes is poorly controlled and for those with postural hypotension (low blood pressure and consequent dizziness when first standing up) or fluid imbalance (Mitra et *al.*, 2007).

2.5.11 Alcohol

Alcohol should be used in moderation and be restricted to persons with diabetes and insulin induced hypoglycemia, neuropathy, and poor control of blood sugar, blood lipids, or obesity (1 serving or 340Ml 5% alcohol for women and 2 servings for men daily) intake (Stephen, 2009).

2.5.12 Vitamins/Minerals

Vitamin/Minerals should meet the recommended levels for good health. Supplements are unnecessary for persons with diabetes except when caloric intake is exceptionally low or the variety of foods consumed is limited. Calcium supplements may be necessary under special circumstances (Mitra *et al.*, 2007).

2.6 Role of Physical Exercise

Physical exercise plays a great role in the management of diabetes. It increases body's response to intrinsic insulin by several mechanisms through increasing the amount of transporters of glucose into the muscle cells (GLUT- 4), insulin receptor substrates (IRS) and muscle mass. More than 75% of the glucose uptake in response to insulin is by the muscular tissue. Physical exercise reduces the fatty acid accumulated within the myocytes, by oxidizing them in such a way that weight is reduced. The fatty acids which concentrate inside the myocytes are released from adipose tissue and are the ones which reduce the GLUT- 4 transportation onto the cell membrane. The way in which physical exercise delivers its desired effect involves the improvement of endothelial function, decrease of the vascular stiffness, improving left ventricular diastolic function and the systemic state of inflammation. Physical exercise also reduces both visceral and peripheral fat mass. Flexibility or stretching exercises, are often suggested to increase the joints range of motion and decrease potential of injuries like muscle strain. Doing these exercises

appropriately, can result in increasing muscular flexibility and joints range since diabetes is associated with increased limitation of joints range of motion. It is recommended that, during stretching, muscles be gradually extended to the point that patient feels the extension but no pain, however, each stretch must to last for about 30 second (Esteghamati *et al.*, 2008).

2.6.1 Intensity of physical exercises

The intensity of physical exercise is crucial and it should be sufficient to cause changes in the cardio respiratory system (Polikandrioti and Dokoutsidou, 2009). People with type 2 diabetics must participate in moderate aerobic (40-60% Vo2 max) and resistive (30-50%) exercises 3-5 and 2-3 sessions per week, respectively, though it is a general recommendation, and an expert in exercise therapy should mold the session with respect to individual conditions (Esteghamati *et al.*, 2008).

2.6.2 Duration of physical exercises

Duration of physical exercise duration should be 30 minutes at the beginning, beginning with 5-10 minutes of warm-up and finalizing with recovery exercises (Colberg *et al.*, 2010).

2.6.3 Frequency of physical exercises

Frequency is another important factor to be assessed during physical exercise so as to avoid worsening of the condition. The lower suggested frequency is three times/week. The safest and correct plan for a diabetic patient is low intensity and long duration physical exercise (Colberg *et al.*, 2010).

2.6.4 Environment for physical exercises

An appropriate environment during exercise is very important because during exercise, excessive heat leads to intense sweating and dehydration, thus if the patient has fever, exercise is forbidden (Polikandrioti and Dokoutsidou, 2009).

2.6.5 Hypoglycemic state

The etiology of hypoglycemia during the day includes inappropriate diet, delay or missed meal, use of alcohol without sufficient carbohydrate intake and physical activity. Increased physical activity in patients who take insulin secreting agents like sulfonylurea may lead to hypoglycemia. Glucose expenditure increases during intense physical exercises. Also, exercises induced hypoglycemia may occur with some delay after workout but it is very rare for hypoglycemia to occur as late as the next morning of an afternoon session of physical exercise. Exercise-induced hypoglycemia is most likely to occur 6 - 14 hours post exertion. However, there is a minimum risk in the type 2 diabetics, who are not on insulin or insulin secreting agents. It is recommended to take some carbohydrate prior to physical exercise, if the serum glucose level is less than 100 mg/dl for type 2 diabetics, who are on insulin or insulin secreting agents. This precautionary measure is not needed for those diabetics who are on metformin, alpha-glucosidase inhibitors or thiazolidinediones and not using insulin or insulin secreting agents (Sigal *et al.*, 2006).

2.6.6 Appropriate footwear

Shoes are the most important physical exercise equipment used in diabetics. Appropriate shoes protect the skin and may decrease the recurrence of diabetic foot ulcers. Advised footwear appropriately for physical exercise along with proper modes of physical exercise for diabetics with diabetic foot neuropathy should be made to the patients. Appropriate

shoes are suggested for aerobic exercises like walking and jogging. Inappropriate shoes may result in impaired blood perfusion to the foot and inflammation due to recurrent focal pressure. Type 2 diabetics with neuropathy must wear shoes with thick bottom layer. They should also frequently examine the internal surfaces of their shoes and look for foreign bodies (Polikandrioti and Dokoutsidou, 2009).

Walking barefooted on hot sidewalks, around the pool or inside hot showers may be dangerous as it may lead to severe burns on their soles. Also, polyester or cotton blend stockings help to keep foot dry and prevent it from blistering. Moist stockings are hazardous given that it may become infected with fungi. Impaired blood perfusion to the feet as a result of stiff footwear is a common etiology for foot injuries. Tight footwear is dangerous given that, it may easily lead to ischemic pressure ulceration. These patients need to wear shoes with enough space around the toes to prevent friction and blistering in the toes. Generally, leather is preferred to plastic given that it molds to the foot and allows air exchange between the foot and the surrounding air. New footwear must be initially worn for short periods until they soften and then foot must be evaluated for any pressure points. It is advised for diabetic patients to choose shoes appropriate for their intended physical exercise (Esteghamati *et al.*, 2008).

2.6.7 Adequate hydration

Adequate hydration is important for diabetic people during physical exercise because dehydration may lead to negative effects such as blood glucose concentration which increases as the body dehydrates during exertion. Also, diabetics with autonomic neuropathy are susceptible to hypotension following exertion if dehydrated. Adequate rehydration may be achieved by drinking 500 ml of fluids about 2 hours prior to the activity. During the physical exercise as well, one must drink fluids frequently with short

intervals, enough to compensate for the amount of fluid lost through perspiration. Care must be taken with exertion in the cold or warm climate as well as avoiding physical exercise in the hot and under direct sun light (Esteghamati *et al.*, 2008).

2.6.8 Diabetic retinopathy

Diabetic people with retinopathy must avoid physical exercises like gymnastics which position the patient's head below the trunk. In severe non-proliferative retinopathy and the proliferative type, exercise activity requiring holding one's breath for long duration or those leading to increased systolic blood pressure over 160 mmHg are forbidden (Colberg *et al.*, 2010).

2.6.9 Diabetic foot

Weight bearing exercise modalities such as long distance walking, slow jogging, and running on the treadmill are not advised for patients suffering from diabetic foot. Patients with active ulceration who intend to exercise during their recovery should opt the activities involving upper extremities such as using arm ergometery. These patients must avoid water exercises until the diabetic ulcer has fully healed (Esteghamati *et al.*, 2008).

2.6.10 Peripheral neuropathy

Physical exercises involving long distance walking which may inflict injury to the foot and these must be avoided by patients with peripheral neuropathy. Physical exercises that require less weight bearing like swimming and cycling are more appropriate for these patients (Colberg *et al.*, 2010).

2.6.11 Autonomic neuropathy

Patients with autonomic neuropathy must start the aerobic routines with only 50% of their potential and then gradually increase it as it gets tolerated. This is because these patients are prone to dehydration and hypothermia due to impaired thirst and temperature regulation. These patients have difficulties in sensing symptoms of hypoglycemia, thirst and hypotension (Sigal *et al.*, 2006).

2.6.12 Diabetic nephropathy

These patients must adhere to light exertions and avoid any physical activities such as weight lifting which require them to hold his/her breath (Colberg *et al.*, 2010).

2.6.13 Hypertension

Diabetic people with hypertension should avoid heavy and strenuous physical activities and instead adhere to more dynamic activities which involve large groups of muscles with light to moderate intensity (e.g. bicycling and biking) (Esteghamati *et al.*, 2008).

2.7 Medication

There are two kinds of drugs that are used to lower blood sugar, improve body's response to insulin or cause weight loss so that the body can improve its ability to regulate insulin and sugar which includes injectable insulin and oral medicine/pills. The choice of drug is based on side effects and one's individualized health profile. Insulin shots are recommended for the patients with inadequate glycaemic control despite taking maximally tolerated doses of other oral medication such as metformin or sulfonyureas. In case of oral agents, there are six classes of oral agents which are used for treatment of type 2 diabetics (Table 2 and Table 3) patients (Das and Pande, 2013).

Table 2: Classes of oral agents

Type of Agent	Mechanism of Action	Generic Names
Biguanides	Decrease hepatic glucose production, increase muscle insulin sensitivity	Metformin
Glucosidase inhibitors	Decrease digestion and absorption of carbohydrate	Acarbose, Miglitol
Sulfonylureas	Increase insulin secretion	Glyburide,Glipizide Glimepiride
Meglitinide	Short-term promotion of glucose-stimulated insulin secretion	Repaglinide
Thiazolidenediones	Increase insulin action in muscle, adipose tissue and probably the liver	Rosiglitazone Pioglitazone
The DPP-inhibitors	Lower risk of GI side effects	Januvia, Onglyza

Source: Das and Pande (2013)

Table 3: Limitation of oral agents

Oral agent	**Limitation**
Glucosidase inhibitors	Can cause hypoglycemia
Thiazolidenediones	Lead to weight gain, swelling, increased risk of worsening heart failure, increased risk of fluid retention at the back of the eyes, an increased risk of developing bladder cancer and a small risk of bone fractures.
Biguanides	Cause gastrointestinal disturbances
Sulfonylureas	They can cause hypoglycemia.
Meglitinide	They can cause hypoglycemia.
The DPP-inhibitors	They can cause pancreatitis or inflammation of the pancreas

Source: Das and Pande (2011)

2.8 Management of Diabetes in Type 2 Diabetics

Management of type 2 diabetes can be achieved through healthy dietary habits. Dietary habits play a great role as an integral management tool for type 2 diabetic patients. It functions as the most treatment i.e. as diet alone or in combination with oral hypoglycemic drugs or insulin in type 2 diabetics. Dietary habits proposed for type 2 diabetics are almost similar to all diabetic patients. Dietary habits alone or in combination with oral

hypoglycemic drugs or insulin is important in the improvement of type 2 diabetes conditions. It normalizes the blood glucose level and reduces or delays the risks and complications related to type 2 diabetes (Stephen, 2009).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

The study was done at Morogoro Regional Hospital in Morogoro urban district. Morogoro urban district covers 260 square kilometers. According to 2012 census, the Morogoro urban has a population of 315 866 with 151,700 being males and 164 166 being females.

3.2 Study Population

The study population involved all type 2 diabetics aged ≥ 18 years living in Morogoro Municipality. The sampling frame comprised of adult diabetic patients both males and females in Morogoro municipality receiving health care in the regional referral hospital.

Inclusion criteria: Inclusion criteria were patients diagnosed in accordance with international standards under regular anti-diabetic drug treatment for at least 1 year; ≥ 18 years old, resident in Morogoro municipal for ≥ 2 years.

Exclusion criteria were: All patients less than 18 years, non-resident type 2 diabetics in Morogoro Municipality, pregnant women and diabetic HIV cases.

3.3 Study Design and Sampling

The study employed was cross sectional in design that allowed data to be collected at a single point in time (Bailey, 1994; Babbie, 1990). The design is simple, inexpensive in terms of resources, less time consuming, flexible, minimize bias and maximize the reliability of data collected (Babbie, 1990).

Purposive sampling was applied to identify individuals living with type 2 diabetes who were already on treatment. Random selection was applied to identify the potential participants to ensure equal re-presentation. All males and females had equal chance of being selected. The sample size was determined by using the formula by Fisher *et al.* (1991).

$n = z^2pq/d^2$ .....(1)

Where by

n = the desired sample

z = the standard normal deviate (which is 1.96 corresponding to 95% CI)

p = proportional in the target population with certain characteristics (0.058)

q =1- p

d = degree of accuracy desired (0.05)

Calculating the value of n,

n = 1.962* 0.058 (1- 0.058)/0.052

n = 84

So, the sample size for the study was 84.

3.4 Data Collection

3.4.1 Construction of a questionnaire

A questionnaire (Appendix 1) was constructed to capture information on diabetic related dietary habits and their influence on diabetic complications among type 2 diabetics. The questionnaire had five sections. Social-economic and demographics, Common complications among type 2 diabetics which included hypertension, kidney problems, eye problems, foot problems, stroke, nerve problems, virginal fungus, sexual problems and hypotension. Biomedical measures to diabetic complications included body mass index,

waist and hip circumference, body fat mass, systolic and diastolic blood pressures and fasting blood glucose. Knowledge, attitude and practices among type 2 diabetics and dietary related habits included the meal pattern of individuals, lifestyle behaviors such as alcohol consumption and smoking as well as physical exercises.

3.4.2 Pretesting the questionnaire

Pre-testing of the questionnaires was done in Singida Regional hospital whereby five type 2 diabetics, were involved. Then questions which were not clear, ambiguous or open to more than one answer.

3.4.3 Training of an enumerator

Research assistant was trained before starting data collection. It was taught on how to ask questions, expected answers, how to record the answers and also how to take biomedical measures.

3.4.4 Administration of the questionnaire

The subjects were interviewed face-to-face at the in Morogoro regional hospital during their monthly diabetic clinics.

3.4.5 Measurements taken

Measurements of body weight, height, waist and hip circumferences, and body fat mass were made.

3.4.5.1 Height

Height was measured using a stadiometer. In case of elderly i.e. ≥ 65 knee height was measured using non-stretchable tape. The individual's height was measured from the ankle to the knee point then converted to normal height using equations i.e. 56.343+2.102TL and 62.682TL+1.889 for males and females, respectively (Fatma, 2012).

3.4.5.2 Weight

Weight was measured by using a digital weighing scale whereby a subject was to stand on the scale with bare feet. Then the measurements were displayed on the screen of the scale were recorded.

3.4.5.3 Waist circumference

Waist circumference was measured using a non-stretchable tape at a level midway between the lower rib margin and iliac crest with the tape all around the body in a horizontal position.

3.4.5.4 Hip circumference

Hip circumference was taken around the widest portion of the buttocks using the stretched tape measure.

3.4.5.5 Body fat mass

Body fat mass was measured using bioelectrical impedance analyzer (BIA). In this system, two foot pad electrodes (pressure contact) were incorporated into the platform of the precision electronic scale in which person's measurements were taken while in contact with bare feet. Then the body fat monitor/analyzer automatically measured weight then body fat mass.

3.4.5.6 Blood pressure

Blood pressure was measured using the Omron digital automatic blood pressure monitor (Model M3, Made in Vietnam). Blood pressure measurements were taken on the left arm above the bend at the elbow while at rest, sitting on a chair. The cuff was wrapped around the left arm and the bulb was squeezed to begin inflation. In few seconds blood pressure and pulse readings were displayed on the large digital panel.

3.4.5.7 Fasting blood glucose (FBG)

Fasting blood glucose was measured using Beta-check machine (lancing device). The test was done in the morning whereby individuals did not eat for at least eight hours before the test. The lancing device was assembled in which lancet was inserted into the holder. Then the finger tip of individual of was pricked with the lancing device to collect blood. Finally, the testing strip was placed into a meter to read a level of the glucose in blood.

3.5 Data Analysis

Quantitative data from questionnaire were coded and analyzed using predictive analysis software (PASW) computer program in conformity with the objectives of the study. Data were cleaned before analysis. Descriptive analysis was used to calculate frequencies, percentages in categorical variables whereby categorical variables such as age, sex, marital status, level of education, occupation and income were changed into dummy before used and continuous data such as anthropometric variables including weight, height, BMI, waist and hip circumferences, waist-hip ratio, body fat mass and blood pressure. Descriptive analysis was done to calculate means and standard deviations. Inferential statistical analysis was employed to determine whether the patterns described in the sample were likely to apply in the population from which the sample was drawn. The relations between variables were determined through multiple linear regression

analysis in which complications were taken as dependent variables that were affected by many other factors (independent variables). Statistical significance was set at $p < 0.05$.

3.6 Ethical Issues

Approval was sought from the Morogoro hospital superintendent before conducting the study. Consent of the participants was obtained orally after they were given the information about the study. Confidentiality of the information was ensured by assigning identification numbers to all subjects. No subject was identified by his/her real name. Subjects had freedom to participate in the study and no coercion was used to recruit them into the study. The subjects were also free to deny participation or drop out of the study at any stage without liability or fear of retribution.

3.7 Limitations of the Study

Limitations of this study were:

(i) Availability of consistent information from the participants was a problem especially on the pattern of meal consumption. As a result, it became difficult to know exactly their meal patterns due to inability to recall.

(ii) Cooperation of the respondents was poor initially, however, the subjects cooperated after understanding the benefits of the study to them.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio economic and Demographic Characteristics of the Respondents

Table 4 summarizes the age and sex distribution of the respondents. The mean age of the respondents was 54 ± 11.98 years (range 20 - 79 years). Out of 84 respondents involved in this study, 27.4% (n = 23) were males while 72.6% (n = 61) were females. The study sample was predominantly females with the majority of the participants aged 41 years and above and a female-to-male ratio of 2:1. This ratio could be explained by the fact that, African women are more prone to obesity and they lack physical exercises relative to men (Rudasingwa *et al.*, 2012). Similar findings were reported by Adebayo *et al.* (2009) in the study of dietary habits and prevalence of obesity among type 2 diabetes patients.

Table 4: Age and sex distribution of the respondents (n = 84)

Age group (years)	Male	Female	Total
20-40	5	8	13
41-60	11	37	48
> 60	7	16	23
Total	**23**	**61**	**84**

Table 5 shows the socio-economic characteristics of the respondents. Results revealed that, majority of the respondents were married (58.3%, n = 49), whereas 23.8% (n = 20) were single, 2.4% (n = 2) were divorced and 15 % (n = 13) were widowed. Education level attained by the respondents were primary school education (48.8%, n = 41) secondary school (27.4%, n = 23) and University education (3.6%, n = 3). About 20.2% (n = 17) of the respondents had not attained any formal education. About 21.4% (n = 18) of the respondents were employed for wage, 20.2% (n = 17) were involved in petty business,

32.2% (n = 27) were farmers, 10.7% (n= 9) were self-employed while 15.5% (n = 13) were dependants. Regarding income, majority of the respondents reported their incomes as inadequate (48.8%, n = 41), while 17.9%, (n = 15) reported their income as enough. About 33.3% (n = 28) reported their income as grossly insufficient to meet their basic needs. More than 61.9% (n = 52) of the respondents had lived with the disease for < 10 years, while 29.8% (n = 25) had lived with the disease for 10 - 20 years. About 8.3% (n = 7) of the respondents had lived with the disease for more than > 20 years.

Table 5: Socio- economic characteristics of the respondents (n = 84)

Social economic characteristics	Number	Percent
Education		
No formal education	17	20.2
Primary school	41	48.8
Secondary school	23	27.4
University/Vocational	3	3.6
Total	**84**	**100**
Occupation		
Employed for wage	18	21.4
Farmer	27	32.1
Petty business	17	20.2
Self employed	9	10.7
Dependants	13	15.5
Total	**84**	**100**
Income		
Enough	15	17.9
Barely enough	41	48.8
Totally inadequate	28	33.3
Total	**84**	**100**
Marital status		
Married	49	58.3
Single	20	23.8
Divorced	2	2.4
Widowed	13	15
Total	**84**	**100**

4.2 Food Consumption

Table 6 summarizes the meal pattern of the respondents. Consumption of 10 groups of foods was assessed among the respondents. These groups were cereals, roots, tubers and bananas, pulses, seeds and nuts, meat and poultry, fruits fruit juices, vegetables, sugars, beer, sodas, milk /milk products, and oils and fats. Cereals (maize meal, millet meals, brown and white breads, chapatti and burns) were consumed by all subjects. Roots, tubers and bananas namely new potatoes, plantains, cassavas, and sweet potatoes were consumed by 96.4% (n = 81) of the respondents, 92.9% (n = 78) of the respondents consumed seeds and nuts (beans, peas, legumes and lentils) while 88.1% (n = 74) of the respondents consumed meat and poultry (red meat, eggs, fish and chicken). About 90% (n = 76) of the respondents consumed fruits and fruit juices (cucumber, watermelon, ripe banana, pineapples, mangoes passions, pawpaw and oranges), 29.8% (n = 25) consumed honey, 19% (n = 16) consumed beverages (beer and soda), 72.6% (n = 61) consumed milk and milk products (milk and yoghurt), 88.1% (n = 74) consumed coconut milk while all of the respondents consumed vegetables (tomatoes, spinach, cabbage, potato leaves, and okra and egg plants).

Foods consumed by the respondents could be categorized into carbohydrate, fat/oil, proteins and vitamins. Carbohydrate foods can be grouped into complex and simple carbohydrate. Regarding proteins, there are animal proteins and plant proteins. Vitamins also are from different sources namely vegetables and fruits. These groups of food can be categorized into high and low glycemic index (GI). Glycemic index (GI) is the measure of how a food containing carbohydrate spikes the blood glucose when ingested. It indicates the ability of the food to spike the glucose level in the blood when the food is consumed (Salas-Salvado *et al.*, 2011). Various foods have different abilities to spike the glucose level when eaten. Some foods have high GI while others have low GI. According to Jeya

(2011), a food GI value of ≥ 70 is considered high, a GI value of 56 - 69 is considered medium while a GI value ≤ 55 is low.

The mostly consumed foods by the participants were of high glycemic index (GI) and medium glycemic index. High GI foods included refined maize "ugali", white breads, chapatti, burns, watermelon, soda, white rice, pineapples and honey while medium GI foods included ripe bananas. These foods were frequently consumed (4 - 7 days times /day per week). Adebayo *et al.* (2009) reported a similar pattern of consumption of foods with high glycemic index in Nigeria. High GI foods raise the blood glucose rapidly which cannot be handled by the body of a diabetic person. A high level of glucose in the body that cannot be cleared by the insulin is diverted to biosynthesis of lipid that is stored in adipose tissue. This leads to greater risk of developing obesity (high levels of body fat and/or greater body mass index), high triglycerides, high "bad" LDL cholesterol, low "good" HDL cholesterol, high blood pressure, increase appetite and exacerbating type 2 diabetes. Increase in these risks can therefore increase chances to a diabetic patient to develop complications. Presence of complications among the subjects could be associated with high intake of foods with high glycemic index.

Low glycemic index and rich fiber foods were also consumed by the respondents. These included vegetables (carrots, pumpkin leaves, amaranths, tomatoes, spinach, cabbage, potato leaves, and okra and egg plants), plantains, nuts, legumes, lentils and peas, eggs, chicken and fish, cucumbers, beans, milk yoghurt and cassavas. The foods were consumed by the respondents in small amount. A study of dietary habits and prevalence of obesity among type 2 diabetes patients in Nigeria revealed that, there was a very low intake of diets with low glycemic index (Adebayo *et al.*, 2009). It is recommended to consume fish at least two or more times per week and vegetables and fruits two to three times in a day

(American Diabetes of Association, 2008). Consuming foods rich in fiber and low glycemic index foods is important since it plays a crucial role in achieving normal blood glucose level, the goal for the management of type 2 diabetes. It contributes positively to the maintenance of blood glucose within normal range and minimizes chances to develop complications related to diabetes (Polikandrioti and Dokoutsidou, 2009).

Dietary fiber also plays an important role in controlling postprandial glycemia, insulin responses, satiety, slows down gastric emptying and intestinal nutrient absorption. The recommended daily intake of fiber for diabetics is 44 to 50 grams (American Diabetes of Association, 2008). High intake of dietary fiber reduces risks for developing complications related to diabetes such as coronary heart disease, stroke, hypertension, obesity, and gastrointestinal disorders by forming part of cardio-protective nutrition therapy, and reducing total cholesterol by 2 to 3% and LDL (bad) cholesterol up to 7%. Therefore, increased consumption of dietary fiber also improves serum lipid concentrations, lowers blood pressure, promotes bowel movements, aids in weight loss, and improves immune functions thus improving the general well-being of an individual. More-ever consumption of less gelatinized (complex) starch such as legumes is highly encouraged because it contains more amylopectin which is slow to digest. Acidic foods such as oranges also slow down the gastric emptying thus reducing the spike in blood glucose (Anderson *et al.*, 2009).

Red meat and coconut milk were also consumed frequently by the respondents (4 - 7 days/week). A study by Mohieldein *et al.* (2011) in Saudi Arabia reported high intake of red meat among type 2 diabetics. High intake of red meat is associated with increased risk of insulin resistance and diabetic related complications (Mohieldein *et al.*, 2011). High consumption of coconut oil could increase the risk to develop Coronary Artery Disease

(CAD) complications because it can lead to more artherogenic lipid profiles and aggravate the condition of type 2 diabetics (Feranil, 2011).

Regarding alcohol intake, only very few subjects (2.4 %, n = 2) consumed alcohol in moderation (2 – 3 days per week). According to American Diabetes of Association (2013), people with type 2 diabetes are advised to take only one alcoholic drink (340 ml, 5% alcohol) per day for women and two drinks per day for men and should take extra precautions to prevent hypoglycemia. Moderate alcohol consumption has been associated with decreased complications of diabetes mellitus such as incidences of heart disease in persons with diabetes, because alcohol has a protective effect on type 2 diabetes through enhancing effect of insulin sensitivity (Kastorini and Panagiotakos, 2009).

Table 6: Meal pattern of the respondents (n = 84)

	Frequency of consumption per week							
	1 day		2-3days		4-7days		Overall	
Food groups	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Cereal							**84**	**100**
White bread	15	17.9	3	3.6	18	21		
Brown bread	3	3.6	7	8.4	4	4.8		
Maize ugali	4	4.8	10	11.9	54	64.3		
Millet ugali	2	2.4	16	19	27	32.1		
Burns	4	4.8	4	4.8	10	11.9		
Chapatti	9	10.7	11	13.1	14	16.7		
Roots, tubers, bananas							**81**	**96.4**
New potatoes	16	19	24	26.9	8	9.5		
Cassava	16	19	14	16.7	8	9.5		
Banana/plantains	11	13.1	27	32.1	33	39.3		
Sweet potatoes	4	4.8	1	1.2	1	1.2		
Pulses, seeds, nuts							**78**	**92.9**
beans	3	3.6	24	2 8.6	40	47.6		
Nuts	18	21.4	16	19	13	15.5		
Peas	19	22.6	3	3.6	3	3.6		
Lentils	9	10.7	3	3.6	0	0		
Legumes	7	8.3	3	3.6	0	0		
Meat and poultry							**74**	**88.1**
Meat	16	19	13	15.5	14	16.7		
Eggs	13	15.5	13	15.5	3	3.6		
Chickens	13	15.5	12	14.3	0	0		
Fish	22	26.2	31	36.9	8	9.50		
Fruits, fruit juices							**76**	**90.5**
Avocado	23	27.4	13	15.5	4	4.80		
Cucumber	6	7.1	11	13.1	53	63.1		
Oranges	20	23.8	19	22.6	7	8.30		
Ripe bananas	22	26.2	5	6	16	19		
Pawpaw	22	26.2	11	13.1	1	1.2		
Watermelon	15	17.9	13	15.5	9	10.70		
Pineapples	15	17.9	6	7.1	1	1.2		
Passions	11	13.1	4	4.8	0	0		
Mangoes	23	27.4	13	15.5	4	4.8		
Vegetables							**84**	**100**
Carrots	7	8.3	11	13.1	49	7		
Pumpkin leaves	24	28.6	45	53.6	2	16.7		
Amaranth	26	31	43	51.2	13	15.5		
Tomatoes	1	1.2	2	2.4	78	92.9		
Spinach	31	36.9	41	48.8	4	4.8		
Cabbage	31	36.9	36	42.9	1	1.2		
Potato leaves	23	27.4	40	47.6	11	13.1		
Okra	20	23.8	23	27.4	4	4.8		
Egg plant	7	8.3	2	2.4	1	1.2		
Sugars							**25**	**29.8**
Honey	4	4.8	5	6	9	10.7		
Beverages							**16**	**19**
Beer	0	0	2	2.4	0	0		
Soda	2	2.4	3	3.6	4	4.8		
Milk /Milk products							**61**	**72.6**
Milk	8	9.5	12	14.3	37	44		
Yogurt	8	9.5	8	9.5	6	7.1		
Oils and fats							**74**	**88.1**
Coconut milk	3	3.6	8	9.5	19	22.6		

4.3 Biological Risks for Diabetic Complications

4.3.1 Weight, Height and Body Mass Index

Table 7 shows the distribution of the BMI of the respondents. The mean weight of the respondents was 69.40 ± 14.04 kg and the mean height was 157.00 ± 8.86 centimeters. The mean BMI of the respondents was 28.20 ± 5.64. More than 42 .7% (n = 34) of the respondents had BMI of 30 and above which implied that, they were obese. About 23.8% (n = 20) of the respondents were overweight, 3.6% (n = 3) had chronic energy deficiency while 32.1% (n = 27) were normal. More than 21.7% (n = 5) of the type 2 diabetic males and 45.9% (n = 28) of the diabetic females were obese. Among the obese females, 2.4 % (n = 2) were extreme.

These results suggested that, the population from which the sample was drawn could be at a risk of macro-vascular complications due to the fact that most of the diabetic patients were obese. Similar findings were reported by Adebayo *et al.* (2009) in Lesotho, whereby, prevalence of obesity among type 2 diabetics was 78%. Among the obese respondents, 57% were males while 81% were females. An increase in BMI is associated with decrease in "good" HDL cholesterol, increase in "bad" LDL cholesterol, triglycerides and high blood pressure. This in turn increases chances of developing macro-vascular complications such as cardiovascular, cerebovascular and peripheral vascular disease which lead to morbidity and premature death for diabetics (Osher and Stern, 2009).

Table 7: Distribution of the BMI of the respondents (n = 84)

Inference	BMI category	Male	Female	Number	Percent
Underweight	<18.5	1	2	3	3.6
Normal	18.5-24.5	9	15	24	31.0
Overweight	25.0-29.9	7	17	24	28.6
Obesity class I	30.0-34.9	6	17	23	27.4
Obesity class II	35.0-39.9	0	8	8	9.5
obesity class III (extreme)	> 40	0	2	2	2.4
Total		**23**	**61**	**84**	**100**

4.3.2 Body fat mass

Table 8 summarizes the body fat mass according to age and sex. The mean body fat mass of both female and male respondents was equal at 30.26 ± 9.83 percent. All males aged 20 - 39 years (4.8%, n = 4) were healthy with body fat mass of 9 to 20%. For males aged 40 – 59 years, 1.2 % (n = 1) were under-fat, 4.8% (n = 4) were healthy, 2.4 % (n = 2) were-over fat while 4.8% (n = 4) were obese. For males aged 60 – 79 years, 8.3% (n = 7) were healthy while 1.2% (n = 1) were obese. All female aged 20 - 39 years were healthy (6 %, n = 5) having body fat mass of 22 to 33%. For female aged 40 - 59 years, 3.6% (n = 3) were under-fat, 19 % (n = 16) were healthy, 11.9% (n = 10) were over-fat while 10.7% (n = 9) were obese. For female aged 60 - 79 years, the body fat mass distribution was 8.3% (n = 7) were under-fat, 10.7% (n = 9) were healthy, while 2.4% (n = 2) were over-fat. Being over-fat or obese can lead a diabetic individual to develop complications. Thus, the over-fat, overweight and obese diabetic patients were at high risk of developing complications. Excess body fat plays a strong role in insulin resistance, but the way the fat is distributed is very important. Fat mass that concentrates around the abdomen and in the upper part of the body (apple-shaped) is associated with insulin resistance and complications such as heart disease, high blood pressure, stroke and unhealthy cholesterol levels (Burke, 2000).

The mechanism might be due to lipolytically sensitive abdominal depots provide excess free fatty acids to the muscle tissue that has limited capacity for their oxidation. This in turn may result in insulin resistance and hyperinsulemia (Esteghamati *et al.*, 2008).

Table 8: Distribution of body fat mass according to age and sex (n = 84)

Inference	Fat category (%)	Age (years)	Male	Female	Number	Percent
Under fat	0-8	20-39	0	0	0	0.0
Healthy	9-20		4	0	4	4.8
Over fat	21-24		0	5	5	6.0
Obese	≥25		0	0	0	0.0
Under fat	0-10	40-59	1	0	1	1.2
Healthy	11-22		4	3	7	8.3
Over fat	23-27		2	16	18	21.4
Obese	≥28		0	10	10	11.9
Under fat	0-12	60-79	0	9	9	10.7
Healthy	13-25		7	7	14	16.7
Over fat	26-30		0	9	9	10.7
Obese	≥31		1	2	3	3.6
Total			**23**	**61**	**84**	**100**

4.3.3 Waist, hip circumferences and waist hip circumference ratio

Table 9 summarizes the distribution of waist circumference (cm) and waist hip circumference ratio according to sex. The average hip circumference for females was 108.75 ± 10.32 cm slightly higher ($p < 0.05$) than that of male (100.72 ± 18.68 cm). Majority of males (52.2%, n = 12), had waist circumference of > 102 cm, 43.5% (n = 10) had mean waist circumference of < 94 cm while 8.7% (n = 2) had waist circumference between ≥ 94 and 102 cm. In case of females, most of them (47.5%, n = 29) had mean waist circumference of > 88 cm, 32.8% (n = 20) had mean waist circumference greater than or equal to 80 - 88 cm while the rest of the females (19.7%, n = 12) had the ideal waist circumference of less than 80 cm. The mean waist circumference for females was

99.37 ± 12.45 cm higher ($p < 0.05$) than that of males (93.86 ± 19.93 cm). The mean waist circumference for men was below the recommended WHO value (94 cm) while that of females was higher than the WHO recommended cut-off points (80 cm) (WHO, 2008). According to Yadav *et al.* (2008), central adiposity indicates deposition of large quantities of abdominal fat, which consists of visceral fat and subcutaneous fat. Visceral fat increases the risk of complications by favoring insulin resistance. Thus, females in this study were at higher risk of developing complications due to high abdominal adiposity.

Females mean waist-hip ratio was 0.93 ± 0.05, higher than that of males (0.91 ± 0.6). About 60.9% (n = 14) of the males had the waist-hip ratio of greater than 0.9 cm while 39.1% (n = 9) of the respondents had the ideal waist-hip ratio of less than 0.9 cm. About 70.5% (n = 43) of the females had waist-hip ratio greater than or equal to 0.85 cm while 29.5% (n = 18) of them had waist-hip ratio of less than 0.85 cm. High waist-hip circumference ratio has been associated with increased visceral fat accumulation leading to insulin resistance, cardiovascular diseases such as hypertension, and dysilipidemia while also increasing duration of living with diabetes (Shah, 2009). Respondents in this study were therefore in a high risk of developing the cardiovascular complications associated with high waist-hip ratio. In this study, more females had waist-hip ratio above the recommended value (<0.85) compared to their male counterparts. These findings were in line with those reported by Odili *et al.* (2012) whereby 92% of males in their study had ideal waist circumference of < 94 cm, while only 45.6% of the females had ideal waist circumference of 80 cm. For the waist-hip ratio, half (50%) of the males and only 4.35% of the females had ideal waist-hip ratio of 0.94 and 0.85, respectively.

Table 9: Distribution of waist circumference (cm) and waist-hip circumference ratio according to sex (n = 84)

Parameter		Male		Female
Waist circumference	**Number**	**Percent**	**Number**	**Percent**
< 94	10	43.5	0	0.00
94-102	2	8.7	0	0.00
≥ 102	11	47.8	0	0.00
Total	**23**	**100.00**	**0**	**0.00**
<80	0	0.00	12	19.7
80-88	0	0.00	20	32.8
≥88	0	0.00	29	45.9
Total	**0**	**0.00**	**61**	**100**
Waist circumference hip ratio				
< 0.94	9	39.1	0	0.00
≥0.94	14	60.9	0	0.00
Total	**23**	**100.00**	0	0.00
<0.85	0	0.00	18	29.5
≥0.85	0	0.00	43	70.5
Total	**0**	**0.00**	**61**	**100**

4.3.4 Blood pressure

Table 10 shows the distribution of blood pressure (mm Hg) according to sex of the respondents. The mean systolic blood pressure of males (145.9 ± 28.9 mm Hg) was slightly higher ($p < 0.05$) than that of female (143.50 ± 24.82 mm Hg) while the mean diastolic blood pressure of male patients was 81.40 ± 13.99 mm Hg slightly lower ($p < 0.05$) than that of female (82.80 ± 12.71 mm Hg). Blood pressure control was poor among the patients in which most of them were hypertensive and very few were normal. Distribution of blood pressure was classified as high blood pressure when systolic pressure was ≥ 140 mm Hg and diastolic pressure of > 90 mm Hg. But, whatever systolic blood pressure was, when diastolic exceeded 90 mm Hg, an individual was considered to be hypertensive. When diastolic pressure was ≤ 60 mm Hg regardless of how systolic blood pressure was, an individual was considered to be hypotensive. Cardiovascular diseases (CVD) are the major contributors to morbidity and depreciation in the quality of life among diabetics (Kalofoutis *et al.*, 2007).

From this study, more than half of the participants (57.2%, n = 48) failed to maintain ideal blood pressure since majority of them were hypertensive (52.4%, n = 44) and only a few were hypotensive (4.8%, n = 4). The subjects were therefore in high risk of developing CVD, kidney problems, eye problems and peripheral vascular diseases since most of them failed to maintain their blood pressures. Blood pressure control is vital in the management of diabetes. High blood pressure increases workload of the heart, arteries and kidneys hence increasing chances for developing a cardiovascular disease (such as a heart attack or stroke) and kidney problems through damaging the small filtering vessels of the kidney. Also, high blood pressure causes damage to eyes and peripheral vascular disease (hardening of the arteries in the legs and feet) which are long-term complications of diabetes (Campbell *et al.*, 2011). A study by Odili *et al.* (2012) in Nigeria on anthropometric measurements and glycaemic control in type 2 diabetic patients showed that, blood pressure control in type 2 diabetic patients with hypertension achieved significant reduction in the complications related to diabetes and risk of deaths related to diabetes.

Table 10: Distribution of blood pressure (mm Hg) according to sex of the respondents (n = 84)

Blood pressure (mm Hg)	Sex	BP	Number	Std deviation
Systolic	Male	145.9	23	28.9
	Female	143.5	61	24.82
Diastolic	Male	81.40	23	13.99
	Female	82.8	61	12.71

4.3.5 Fasting blood glucose (FBG)

Table 11 shows the distribution of FBG (mmol/L) among the respondents. The average of FBG for the respondents was 9.37 ± 3.97 mmol/L. The mean FBG for male patients was 9.3 ± 4.8 mmol/L while for female patients were 9.40 ± 3.70 mmol/L. Out of 84 respondents, 45.20% (n = 38) had normal FBG, 23.80% (n = 20) had elevated FBG while 31.00%, (n = 26) had very high FBG. The average level of fasting blood glucose of the study sample (9.37 mmol/L) was above the recommended level 7.00 mmol/L for reducing diabetic related complications (American Diabetes of Association, 2009). Also, most of the respondents (54.80, n = 46) did not have the ideal FBG level. These findings were similar to those reported by Odili *et al.* (2012) whereby fasting blood glucose levels were found to be high among the type 2 diabetics, and less than 30% of the patients had FBG levels within the normal range of 4 – 7 mmol/L. Glucose monitoring is essential for diabetic patients because it helps to manage the disease and avoid its associated complications (American Diabetes of Association, 2011).

Table 11: Distribution of FBG (mmol/L) among the respondents (n = 84)

Fasting blood glucose(mmol/L)	Age group (years)						Overall
	20-39		40-59		60-79		
	Male	Female	Male	Female	Male	Female	
4 -7	2	2	0	1	3	5	13
7.1-11	5	17	5	8	8	5	48
>11	1	11	2	4	1	4	23
Total	8	30	7	13	12	14	84

4.4 Knowledge, Attitude and Practices of Type 2 Diabetics about Diabetes Management

4.4.1 Knowledge

4.4.1.1 Diet

Table 12 summarizes the knowledge about diet of the diabetics. Most of the diabetic patients were familiar with the diets that they were supposed to consume due to their condition. The respondents were asked six questions. Subjects who scored 3 - 6 out of six were considered to have high knowledge about diet for diabetes disease while those who scored less than 3 were considered to have low knowledge about diet for diabetics. Data shows that, majority of the respondents (96.4%, n = 81) had high knowledge about dietary management of diabetes. Low income was reported to limit the intake of the diets. Dietary knowledge for diabetic patients might have an important role in reducing chances of developing diabetic complications. Cultural background and dietary education from the monthly clinic might have contributed to the high knowledge on dietary management. These findings were similar to those reported by Mukhopadhyay *et al.* (2010) on perception practices of type 2 diabetes in India. Dietary knowledge was favorable in 82.8% diabetics. Moreover, patient's knowledge on recommended diets reflected their dietary habits which influenced their food selection and eating patterns. Low income was a limiting factor for intake of the recommended foods. A study done by Shah *et al.* (2009) in India also reported high level of dietary knowledge among type 2 diabetes individuals. Generally, knowledge about dietary management of diabetes was important in reducing the incidence and morbidity associated with type 2 diabetes mellitus.

Table 12: Knowledge about diet of diabetics (n = 84)

Knowledge category	Scores	Number	Percent
Low	<3	3	3.6
High	3-6	81	96.4
Total	**6**	**84**	**100**

4.4.1.2 Medication

Table 13 shows the level of knowledge about medication among the respondents. Five questions were asked to the respondents about management of diabetes by medication. A score of < 3 out of five was considered as a low knowledge while a score of 3 - 4 was considered as high knowledge. Majority of the respondents scored high knowledge on medication (88.1%, n = 74), however income was a limitation for management of diabetes. This could have contributed to the increase in complications among diabetic subjects. Patients' knowledge about diabetes management was associated with better medication adherence. Adherence to medication was crucial to control blood glucose. Non adherences to medications among diabetic patient's results in poor glycaemic control and hence increase in the risk of developing chronic complications (American Diabetes of Association, 2013).

Table 13: Level of knowledge about medication among the respondents (n = 84)

Category	Scores	Number	Percent
Low	< 3	10	11.9
High	3 - 4	74	88.1
Total	**4**	**84**	**100**

4.4.1.3 Physical exercises

Table 14 summarizes the respondents' knowledge about physical exercises and its role in diabetes management. In case of physical exercises, four questions were asked about management of diabetes by physical exercise. A score of 3 - 4 out of 4 was considered high knowledge while scoring < 3 was considered low knowledge. Most of the respondents (96.4%, n = 81) had low knowledge about the benefits of physical exercises in the management of diabetes. The findings of this study were contradicting those of a study done by Shah *et al.* (2009) who reported high level of knowledge regarding the benefits of physical exercises among type 2 diabetes individuals. Physical exercise is essential in the management of diabetes because it increases the body's response to intrinsic insulin, by multiple mechanisms including increasing the amount of transporters of glucose into the muscle cells (GLUT- 4), increasing the insulin receptor substrates (IRS) and increasing the muscle mass. It is recommended that, diabetic people should participate in moderate physical exercises in at least 2 – 5 times per week (Esteghamati *et al.*, 2008). Knowledge on physical exercise is vital for management of diabetes and its associated complications as it reduces insulin resistant. Lack of knowledge about the importance of physical exercises to diabetic subjects may have contributed to the development of complications among the subjects.

Table 14: Respondents' knowledge about benefits of physical exercise in the management of diabetes (n = 84)

Category	Scores	Number	Percent
Low	<3	81	96.4
High	3-4	3	3.6
Total	**4**	**84**	**100**

4.4.2 Attitude

Table 15 shows the respondents' attitudes regarding diabetes management. Four questions were asked about attitudes in the management of diabetes mellitus. A score of 3 - 4 out of 4 was considered to be positive attitude while a score of < 3 was considered as a negative attitude. Most of the respondents had positive attitude about diet 83.3% (n = 70), medication (91.7%, n = 77) and physical exercises (33.6%. n = 28). All of the respondents believed that, following a low fat diet was very helpful to a diabetic patient. More than 83.3% (n = 70) of the respondents believed that, consumption of complex carbohydrate was of their help to health. These findings were slightly different from those reported by Mukhopadhyay et *al.* (2010), whereby majority of the respondents in India had more positive attitude towards diet in the management of type 2 diabetes than medication and physical exercises. Although many respondents had positive attitudes with medication and diet as the major factors that influence their health, low income limited their ability to practice on medication and purchase the foods appropriately for their condition. A study done by Al-Qazaz *et al.* (2011) also reported that, majority of the respondents had positive attitude towards medication than diet and physical exercises. Positive attitude towards diet, medication and physical exercises was important for management of diabetic complications as the attitude influences their practices in the management of their condition.

4.4.2 Attitude

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Table 15: Respondents' responses regarding diabetes management (n = 84)

Attitude	Number	Percent
Diet		
Is following a low fat eating plan helpful	84	100
Was eating complex carbohydrate of any help?	70	83.3
Do you believe reducing caloric intake will help you to reduce weight?	26	31.0
Is intake of high in dietary fiber of health benefit?	81	96.4
Do you believe in eating a lot of fruits and vegetables (at least 5 servings per day) as healthy?	61	72.6
Do you agree that eating few sweets was healthy?	84	100
Medication		
Do you believe in testing your blood sugar regularly?	84	100
Is it important to checkup for blood pressure regularly?	84	100
Is it important to checkup for eyes regularly?	84	100
Is it beneficial to checkup for bodyweight regularly?	56	66.7
Physical exercise		
Are exercises important on daily basis?	84	100
Do we need exercise continuously for at least 20 min at least 3 times per week?	17	20.2
Do we need to fit exercise into our daily routine (taking stairs , walking to work)	6	7.1
Do we need to engage in specific amount, type duration and level of exercise	6	7.1

4.4.3 Practices

4.4.3.1 Diet

Table 16 shows reasons given by the respondents for food consumption. The most commonly consumed meal by all respondents was cereal while the other foods were consumed only in little amount. Reasons given for consuming cereal based meals were the low costs, short time of preparation, easy availability (66.7%, n = 56) and/or healthy/nutritional benefits (33.3%, n = 28). This implied that, majority of the respondents had low income, lacked appropriate nutrition information from health care providers and used locally available foods without considering their diabetic conditions. These poor dietary practices could have enhanced diabetic complications among the respondents.

These findings were similar to those reported by Kiberenge *et al.* (2010), in which, majority of the respondents (75.6%) had poor dietary practices. A study done by Ikombele (2012) also reported that, majority of the respondents had poor dietary practices which were attributed to limited resources and low income which limited their ability to purchase the appropriate foods for their condition.

Table 16: Reasons given by the respondents for food consumption (n = 84)

Category	Number	Percent
Healthy benefit	28	33.3
Low cost/advice/availability/easy preparation	56	66.7
Total	**84**	**100**

4.4.3.2 Foot care practices

Table 17 shows the foot care practices among the respondents. Seven questions were asked concerning foot care practices. Majority of the respondents (85.7%, n = 72) showed good foot care practices with the exception of one aspect of applying moisturization cream/oil when the skin was dry. Checking the inside of the shoes before wearing was a good practice because it helped to check if there was anything that could injure the foot. According to ADA (2011), diabetic patients are advised to inspect their feet daily and seek health care as early as possible in case of foot injury. Foot wounds are the most common diabetes related cause of hospitalization and is the most common cause of traumatic amputation of lower limbs. The practices were necessary to prevent foot injury and infections. Most of the respondents never soaked their feet (94%, n = 79). This implied that, majority of the subjects had good foot care practices for their feet since soaking was not good for a diabetic patient because soaking the feet makes the skin susceptible to infections.

Table 17: Foot care practices among the respondents (n = 84)

Foot care Practices	Number	Percent
Wash feet with soap and water every day	82	97.6
check the feet daily for skin breaks, blisters, swelling, or redness	60	71.4
Apply moisturizing cream/oil after the skin is dry	28	33.3
Make sure the appropriate use footwear	67	79.8
Avoid activities that can injure the feet	17	20.2
Use care when trimming the nails	74	88.1
Soaking feet	79	94

4.4.3.3 Medication practices

Majority of the respondents (96.4%, n = 81) used medicine as part of their diabetes management. Among the respondents, 7.1% (n = 6) used injectable insulin while 89.3% (n = 75) used pills (tablets). About 75% (n = 63) of the respondents obtained medication from hospitals, 6% (n = 5) from pharmacies and 15.5% (n = 13) from either pharmacies or hospital. The frequency of using medication per day ranged from once (23.8%, n = 20), twice (64.3%, n = 54) to thrice (3.6 %, n = 3). Medical check-ups for blood sugar for most of the respondents was once per month (66.7%, n = 56). In case of eye check-ups, 88.1% (n = 74) of the respondents did not check the eyes once every month. Majority of the respondents did not check their blood pressures until they attended their monthly diabetes clinics. Body weight check-ups ranged from once per month (34.5%, (n = 29), twice per month (9.5%, n = 8) while 55.9% (n = 47) did not check their body weights at all. Medical check-ups especially of eyes and body weight which appeared not to be practiced well by most of the respondents are very important for diabetes management. These findings were similar to those reported by Gun (2010) who reported that, check-ups of the blood pressure, body weight and eyes in Pakistani was rare among type 2 diabetics. According to ADA (2013), a diabetic individual should check his/her blood glucose at least twice per day. Regular testing of blood sugar is important because it helps to determine how well

diabetes management aspects such as diet, physical exercises and medication (where applicable) are working to keep blood glucose as close to normal as possible.

The closer to normal a diabetic patient keeps his/her blood glucose, the more he/she prevents diabetic complications such as eye diseases, nerve damage and cardiovascular diseases. Regular testing of blood pressure is also important for diabetic patients in order to keep it in the normal range or as close to normal as is safely possible. It is recommended that, diabetics patients should test their blood pressure during routine visit to their healthcare providers and that the target treatment goal for high blood pressure be revised from < 130 mm Hg to < 140 mm Hg for systolic while diastolic blood pressure should be ≤ 80 mm Hg to < 90 mm Hg (Fowler, 2008). Apart from their routine visits to their health care providers, diabetic patients should test their blood glucose levels from three or more times per day to event-specific times that may call for much more testing (ADA, 2013). Weight loss medications may be considered in the treatment of overweight and obese individuals with type 2 diabetes and can help achieve a 5 – 10% weight loss when combined with lifestyle modifications. The importance of controlling body weight in reducing risks related to diabetes is of great importance (ADA, 2013). Eye check-ups is also important in order to prevent blindness.

4.4.3.3 Physical exercises

Table 18 summarizes the types and frequency of physical exercises performed by the respondents. Majority of the respondents did not perform physical exercise apart from low level of walking daily (66.7%, n = 56). Other physical exercises that were performed by few participants were, jogging (15.5%, n = 13), swimming (1.2%, n = 1), basketball (1.2%, n = 1), riding a bicycle (6%, n = 5), stretching (3.6%, n = 3), jumping (4.8%, n = 4) and gym use (1.2%, n = 1). Most of the respondents walked at the average intensity of 30

min per day while only a few walked more than 30 minutes per day. For the respondents who jumped daily half of them jumped for an average of 15 minutes while the rest jumped for an average of 60 minutes.

Respondents who participated in daily jogging had on average intensity of less than or equal to 30 minutes per day. Gym use was rarely used and was used at average of 30 minutes per day. Stretching was done at an average of 5 minutes, while bicycling was done at an average of 60 minutes to 240 minutes per day. Basketball was done at an average of 90 minutes per week. Reasons given by the respondents for performing physical exercises were health benefits /normalizing blood glucose (76.2%, n = 64). For those who did not do physical exercises, the reasons advanced were laziness (6%, n = 5) and sickness (3.6%, n = 3). Lack of physical exercises increase the risk for diabetic complications. Duration of physical exercises should be 30 minutes in the beginning, starting with 5-10 minutes of warm-up and finish always with recovery exercises (Esteghamati *et al.*, 2008).

Physical exercises affect the skeletal muscle glucose transport in two ways. The first effect is on the insulin-independent stimulation of glucose transport which occurs during and shortly after physical exercise. The second effect is on the increase in insulin sensitivity which occurs as the glucose transport dissipates (Tucker *et al.*, 2008). Physical exercises increase the body's response to insulin by increasing the amount of transporters of glucose into the muscle cells (GLUT 4), insulin receptor substrates (IRS) and muscle mass (Esteghamati *et al.*, 2008). The major mechanism for physical exercises and insulin-induced increase in blood glucose uptake involves the translocation of GLUT 4 from intracellular regions to the cell surface. This translocation of GLUT 4 is in response to either muscle contraction or a signaling cascade that begins with insulin binding to the

receptors on skeletal muscle. The receptors on skeletal muscle then phosphorylate and activate insulin receptor substrate-1 (IRS-1) which converts phosphatidylinositol bisphosphate (PIP2) to phosphatidylinositol trisphosphate (PIP3). PIP3 then binds to protein kinase B (PKB) which then activates pyruvate dehydrogenase kinase-isozyme 1 (PDK1) to phosphorylate PKB. PKB phosphorylates targets that stimulate GLUT 4. The transport of glucose across the plasma membrane represents the rate limiting step in glucose utilization. Thus, the effects of physical exercises on glucose homeostasis occur primarily due to increased GLUT 4 traffic, as opposed to enhanced insulin signaling at the level of the insulin receptor, IRS-1, IRS-2, or PI3-kinase (Tucker *et al.*, 2008). Therefore, physical exercise is very important for a diabetic individual because it reduces insulin resistance and clears glucose in the blood stream.

Table 18: Types and frequency of physical exercises performed by the respondents (n = 84)

Type of exercise	Average time/week (min)	Number	Percent
Walking	210	56	66.7
Jogging	210	13	15.5
Swimming	210	1	1.2
Basketball	90	1	1.2
Riding a bicycle	210	5	6.0
Stretching	35	3	3..6
Jumping	210	4	4.8
Gym use	210	1	1.2
Total		**84**	**100**

4.5 Diabetic Complications Associated with Type 2 diabetes Mellitus

Table 19 shows diabetic complications reported by the respondents. The study revealed that, majority of the respondents had experienced at least one, two, three and/or four diabetic complications. Patients with hypertension were 51.2% (n = 44). About 68% (n = 58) of the patients had eye complications, 25% (n = 21) had foot problems, 4.8% (n = 4),

had kidney complications, 47.6% (n = 40) had nerve complications, 14.3% (n = 12) had vaginal fungus, 7.1% (n = 6) had sexual problems while 4.8% (n = 4) had hypotension. Causes for the complications that were given out by the respondents included, high blood sugar, dietary habits, failure of the pancreas, aging, malaria, high blood pressure, lack of physical activities, consumption of sugary foods, depression, local drugs, salty foods, and stress. Based on the causes of complications reported by the respondents, most of them did not know what actually caused the complications. These findings were in agreement with those reported by Sethi *et al.* (2011) who found that, 30% only of the respondents in their study knew the root causes for the type 2 diabetes complications while 70% did not know the causes.

Exploring patients' knowledge on the root causes of diabetes complications is important to gain a better understanding of how patients may approach their disease management. Only few of the respondents provided fairly scientifically accurate physiological descriptions of the disease. Knowing if persistent of high glucose levels can cause complications through damage of blood vessels, nerves and organs could help the subjects to control their blood glucose thus reducing the chances to develop complications. Also, knowing about the disease and the cause of the disease complications is important because it prevents or delays the onset of diabetes complications through controlling the blood glucose (ADA, 2011). Since most of the respondents did not know about the cause of the diabetic complications, the study subjects were at risk of developing diabetic complications.

Most of the respondents controlled diabetic complications by medication, physical exercises as well as dietary methods. About 89% (n = 75) of the respondents used pills (tablets), while 6.7% (n = 6) used injectable insulin. About 56% (n = 47) of the respondents managed their complications by eating complex carbohydrate foods, 19% (n

= 16) ate just little foods with high amount of vegetables without considering whether the type of carbohydrate was complex or not, while 25% (n = 21) followed the dietary advice from the doctors. Regarding physical exercises, most of the respondents managed their conditions by walking (58.3%, n = 49), jogging (9.5%, n = 8), riding bicycle (2.4%, n = 2), use of gym (1.2%, n = 1), stretching (3.6%, n = 3) and basketball (1.2%, n = 1). Ideally, the initial management of type 2 diabetes should be based on dietary therapy combined with increased physical activity, if possible. Medication (oral hypoglycemic drugs or insulin) may be considered in the presence of marked hyperglycemia (Stephen, 2009). Since majority of the respondents used medication, it seemed that, subjects did not target to control their blood glucose using dietary therapy and physical exercises.

Regarding other lifestyle behaviors which influence diabetic complications, the study revealed that, out of all respondents, only 7.1% (n = 6) were taking alcohol. There was no respondent who smoked. Reasons advanced for not smoking or taking alcohol included religious beliefs, dislike, cultural restrictions, healthy reasons, vomiting, being diagnosed with diabetes, and low economic status. Excessive alcohol intake may contribute to excess energy intake and obesity, induction of pancreatitis, disturbance of carbohydrate and glucose metabolism, and impairment of liver function. Cigarette smoking may cause elevation of blood glucose concentration, increase insulin resistance (Bazzano *et al.*, 2005) and cause inadequate compensatory insulin secretion response (Joseph, 2010). This could be due to a direct effect of nicotine or other components of cigarette smoke on beta cells of the pancreas. These findings were similar to those reported by Joseph (2010), where some of the respondents stopped smoking and taking alcohol after they were diagnosed to be type 2 diabetic

Table 19: Diabetic complications reported by the respondents (n = 84)

Type of complication	Number	Percent
Hypertension	44	51.2
Kidney problems	5	6.0
Eye problems	58	68.0
Foot problems	21	25.0
Nerve problems	40	47.6
Vaginal fungus	12	14.3
Sexual problems	6	7.1
Hypotension	4	4.8
Total	**84**	**100**

4.5.1 Factors predicting diabetic complications

Table 20 summarizes the standardized Beta coefficients and level of significance for factors predicting diabetic complications among type 2 diabetics. A multiple linear regression model was run to check factors predicting diabetic complications. Complication was taken as a dependent variable which was affected by many other factors (independent variables). The model was able to explain 43.5% of the variation for diabetic complications. Among the factors, age and sex of the respondents were strong predictors of diabetes related complications ($p = 0.01$ and $p = 0.03$, respectively). Other factors such as occupation, marital status and education level had positive but insignificant effect on the diabetic related complications. They were therefore weak predictors of diabetic complications.

For the anthropometric factors, only waist-hip ratio was a strong predictor for diabetic complications ($p = 0.04$). Other biomedical factors such as body fat mass, fasting blood glucose, diastolic blood pressure and systolic blood pressure were weak predictors of diabetic related complications. Also, variables such as body mass index and waist circumference were also weak predictors of diabetic complications. Alcohol intake was not a strong predictor of diabetes related complications ($p = 0.181$) may due to the small

amount of consumption reported per day. None of the respondents was smoking at the time of data collection. Thus, prediction value of smoking on the occurrence of diabetic complications could not be established.

Lack of knowledge and poor practices in some aspects about food consumption was found to have significant influence on the number of complications. Among the ten groups of foods consumed by the respondents (cereals, roots, tubers and bananas, pulses, seeds and nuts meat and poultry, fruits and fruit juices, vegetables, sugars, drinks, milk /milk products, and oils and fats), significant association with diabetic complications was found only in vegetables ($p = 0.01$). For the rest of the food groups, there was no significant association with the diabetic complications reported among the diabetic patients. Although the strengths of association between the rest of the food groups and diabetic complications was not significant ($p > 0.05$), however, some of the food groups had positive beta coefficient values, suggesting that, they influenced the complications positively.

This observation was in line with findings by Liu *et al.* (2010) who reported, as the age of a diabetic patient increased, it increased the chance of diabetic complications significantly. Sex was also the predictor of complications. This could be explained by the fact that, African women are culturally, more susceptible to obesity and lack physical exercises than men (Rudasingwa *et al.*, 2012). Also, Liu *et al.* (2010), reported that, sex of the diabetic patient was found to influence diabetic complications where-by complications among female subjects were significantly higher than among male subjects. Also, findings reported by Tol *et al.* (2012) demonstrated significant association of sex and age with complications of diabetes.

Regarding waist-hip-ratio, it was also a strong predictor of diabetes complications. In the study of anthropometric measurements and glycaemic control among type 2 diabetes patients, Odili *et al.* (2012) observed that, waist-hip-ratio of diabetic subjects was associated with increased diabetic complications because central adiposity increases insulin resistance. Also, Sethi *et al.* (2011) in a study of risk factors for the high prevalence of type 2 diabetes in India reported that, waist-hip-ratio was strongly associated with increase in diabetc complications. A study done by Mohieldein *et al.* (2011) in Saudi Arabia observed that low intake of vegetables was strongly associated with diabetic complications among type 2 diabetics. This observation underline the fact that, although there are many factors which influence diabetic complications such as accessibility to health facilities, dietary habits are vital aspect for successful control of diabetic related complications (Stephen, 2009).

Table 20: Standardized Beta coefficients and level of significance of factors predicting diabetic complications among type 2 diabetics

Significant predictors	Standardized coefficients Beta	t-value	P-value
Constant		-2.286	.026
Age of respondent	0.411	2.761	.01
Sex of respondent	0.251	2.206	.031
Education level of respondents	0.036	-.194	.847
Occupation of respondents	0.105	1.268	.210
Income of respondents	-0.044	.534	.595
Marital status of respondents	0.060	.088	.930
BMI of respondent	-0.282	-1.087	.281
Waist circumference	-0.106	-.640	.525
Waist-hip ratio	0.363	2.007	.049
BFM	0.035	.483	.631
SBP	0.205	1.459	.150
DBP	-0.004	.170	.866
FBG	0.119	1.113	.270
Alcohol	-0.177	1.353	.181
Physical exercise	0.246	-.133	.895
Cereal	-0.090	-.501	.618
Roots, tubers and bananas	0.217	1.100	.276
Pulses, seeds and nuts	-0.121	.216	.830
Meat and poultry	0.025	.445	.658
Fruits and fruit juices	0.201	1.455	.151
Vegetables	-0.248	-2.697	.01
Sugars	0.000	-.128	.899
Drinks(Beer and soda)	0.169	1.368	.177
Milk /milk products	0.083	.563	.576
Oils and fats	-0.137	-1.537	.130

Dependent variable: Number of complication

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the findings of this study, it may be concluded that, meal pattern, medication and physical exercises, were not followed by the diabetic patients as recommended. Important biomedical measurements, namely body mass index, waist and hip circumferences, body fat mass, blood pressure and fasting blood glucose were higher than levels recommended for diabetics subjects. Most of the respondents had good knowledge and positive attitudes towards diet, but low income was the major limiting factor which led to poor practices of food consumption. Respondents had poor knowledge about benefits of physical exercises and medication but despite positive attitude about benefits of medication and physical exercises, low income was still a limiting factor for accessing medication. Most of the respondents had good foot care practices. There was therefore a strong influence of dietary habits on the diabetic complications among type 2 diabetics. Factors that were strong predictors of diabetes, related complications were age, sex, waist-hip-ratio and vegetables consumption.

5.2 Recommendations

i. There should be nutritional educators who are properly trained on management of type 2 diabetes. Also, there should be guidelines to be used and followed by all players in the management of type 2 diabetes,

ii. Based on the findings, educators should put emphasis on dietary habits and lifestyle behaviors especially for food selection such as low GI foods/complex carbohydrates which are locally available. Educators should also explain the role

of physical exercises in clearing out glucose and insulin resistance. Also, diabetic patients should be taught to monitor their biomarkers for diabetes (Blood pressure, fasting blood glucose, body fat mass, body mass index, waist and waist hip circumferences), for diabetes regularly. Check-ups also should be made according to recommendations such as measuring diabetic biomarkers in each visit to the diabetic clinic every time the patient visits the diabetic clinic.

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APPENDICES

DIETARY HABITS AND THEIR RISKS TO DIABETIC COMPLICATIONS AMONG TYPE 2 DIABETICS IN MOROGORO MUNICIPALITY

Appendix 1: Questionnaire

SECTION A. RAPORT

1. Name.....
2. Health centre.....
3. Age.....
4. Sex..... M/F
5. Your highest level of education. (Select one)
   i) No schooling ii) Primary School iii) Secondary School
   iv) Vocational education v) College/University
6. a) Your occupation
   i) Employed for wage ii) Farmer iii) Petty business iv) Self employed
   v) Other (specify).....
   b) How adequate is your income to meet your daily living expenses
   i) Enough ii) Barely enough iii) Totally inadequate
7. Marital status
   i) Single ii) Married iii) Divorced iv) Widowed
8. When were you diagnosed with diabetes.....
9. What was the last time you tested your blood glucose.....
10. How often do you test your blood glucose.....

SECTION B.

OBJECTIVE I. TO IDENTIFY BIOLOGICAL RISKS OF DIABETIC COMPLICATIONS BIOLOGICAL INFORMATION

a. Weight (kg) .....
b. Height (cm).....
c. Waist circumference.....
d. Hip circumference.....
e. Waist: Hip ratio.....
f. Body fat mass.....
g. Blood pressure (millimeters of mercury (mmHg) i) Systolic..... .ii) diastolic.....
h. Blood glucose (fasting) (mg/dl).....

OBJECTIVE II. TO IDENTIFY TYPES OF DIABETIC COMPLICATIONS ASSOCIATED WITH TYPE 2 DIABETICS

1. Have you ever had any of the following conditions (tick as appropriate)
a) Hypertension b) Kidney problems c) Eye problems d) Foot ulcers e) Stroke f) Nerve problems

2. What are the possible causes of the mentioned conditions?

Condition	Cause
Hypertension	
Kidney problems	
Eye problem	
Foot ulcers	
Stroke	
Nerve problems	

3. How do you manage the above conditions by?
i) Dietary method.....
ii) Medical method.....
iii) Physical method.....
4. Do you take alcohol? Y/ N
5. If yes, why? .....
6. If no why? .....
7. Do you smoke? Y/N
8. If yes why? .....
9. If no why? .....
10. Do you check your feet daily / weekly Y/N
11. How often do you wash your feet.....
12. How often do you soak your feet.....
13. How often do you dry your toes after washing.....

Medical records confirmation
14. Presence of the following conditions
a) Hypertension b) Kidney problems c) Eye problems d) Foot ulcers e) Stroke f) Nerve problems g) Others specify.....

OBJECTIVE III. TO INVESTIGATE THE KAP OF TYPE 2 DIABETICS ABOUT DIABETES MANAGEMENT

A. KNOWLEDGE

a. diet

1. What is the health benefit of having proper diet? .....
2. Please check all that apply
   - i. follow a low fat eating plan
   - ii. Follow a complex carbohydrate plan
   - iii. Reduce the number of calories you eat to lose weight
   - iv. Eat lots of food high in dietary fiber
   - v. Eat lots of fruits and vegetables (at least 5 servings)
   - vi. Eat very few sweets(e.g. desserts, non diet sodas, candy bars)
   - vii. Others (specify) that apply to your food selection.....

b. Medication

3. Please check all that apply
   - i. I test my blood sugar regularly (monitoring)
   - ii. I have no access to blood sugar testing service
   - iii. Testing blood glucose is too expensive for me
   - iv. I use insulin shot 1or 2 times a day
   - v. I use insulin shot 3 or more times a day
   - vi. I use diabetes pills to control my blood glucose
   - vii. I have not been prescribed either insulin or pills for my diabetes

a. Physical exercise

4. Please check all that apply
   - i. I get low level exercise(walking)on a daily basis
   - ii. I exercise continuously for at least 20 min at least 3 times per week
   - iii. I fit exercise into my daily routine (taking stairs , walking to work)
   - iv. I engage in specific amount , type duration and level of exercise
   - v. Any other physical exercise performed.....
5. The most accurate method of monitoring diabetes is .....

B. ATTITUDE

Attitude	Yes	No
Diet		
Is following a low fat eating plan helpful		
Was eating complex carbohydrate of any help?		
Do you believe reducing caloric intake will help you to reduce weight?		
Is intake of high in dietary fiber of health benefit?		
Do you believe in eating a lot of fruits and vegetables (at least 5 servings per day) as healthy?		
Do you agree that eating few sweets was healthy?		
Medication		
Do you believe in testing your blood sugar regularly?		
Is it important to checkup for blood pressure regularly?		
Is it important to checkup for eyes regularly?		
Is it beneficial to checkup for bodyweight regularly?		
Physical exercise		
Are exercises important on daily basis?		
Do we need exercise continuously for at least 20 min at least 3 times per week?		
Do we need to fit exercise into our daily routine (taking stairs , walking to work)		
Do we need to engage in specific amount, type duration and level of exercise		

C. PRACTICES

i) Dietary practices

1. What food do you eat as full meals during
   a. Breakfast..... b. Lunch.....
   c. Dinner.....
2. What do you eat as snacks.....
3. What are the reasons for your food choices? Select as appropriate
   a) Low cost b) Attractive advertisement c) Enjoy the taste d) Serves time in preparation
   e) My friends also likes to eat/ advise from friends f) Parents/Guardians advise g) Health/nutritional benefits
   a) Others specify.....

ii) Medical practices

a. Any medicine used Y/N
b. Regime
   - Injectable insulin
   - Pills
c. Where do you obtain them.....
d. Frequency of use.....
e. How often do you do medicinal checkups for blood sugar.....
f. How often do you do checkups for blood pressure.....
g. How often do you do checkups for eye.....
h. How often do you do checkups for your body weight.....
i. How often do you check your feet.....
j. How often do you check the inside of your shoes.....

iii) Physical method

1. Do you do any exercise daily? Y/N
2. If yes what type of exercise do you do?
    1. walking
    2. Joking
    3. Swimming
    4. Football
    5. Basketball
    6. Netball
    7. Others (specify).....

3. Exercise intensity per day/week/month

Type of exercise	Average time/day	Average time/week	Average time/month

4. Why do you exercise.....
5. If no why don't you exercise?.....

6. How do you take care of your feet? Select the appropriate

a)Wash feet with soap and water every day and check the feet daily for skin breaks, blisters, swelling, or redness b) Apply moisturizing cream/oil after the skin is dry c) Make sure the appropriate use footwear d) Avoid activities that can injure the feet e) Use care when trimming the nails

OBJECTIVE IV: TO ASSESS MEAL PATTERN OF INDIVIDUALS WITH TYPE 2 DIABETES FOOD FREQUENCE QUESTIONNAIRE (HABITUAL FOOD INTAKE)

Food items	Frequencies/ amount (units) per				Glycemic index status(low/high
	Day	Week	Month	Never	
Cereals					
Biscuits					
White bread					
Cake					
Brown bread					
Donut					
Macaroni or spaghetti					
Maize ugali					
Millet ugali					
Chapatti					
Mixed porridge with maize					
Porridge mixed with rice					
Boiled/fried white rice					
Boiled/fried brown rice					
Roots, tubers, bananas					
New potatoes					
Cassava					
Banana/plantains					
Sweet potatoes					
Pulses, seeds, nuts					
beans					
Nuts					
Peas					
Lentils					
Legumes					
Meat and poultry					
Meat					
Eggs					
Chickens					
Fish					
Fruits, fruit juices					
Avocado					
Cucumber					
Oranges					
Ripe bananas					
Pawpaw					
Watermelon					
Pineapples					
Passions					
Grapes					
Apples					

Mangoes					
Baobab					
Apricots					
Vegetables					
Carrots					
Pumpkin leaves					
Amaranth					
Tomatoes					
Spinach					
Cabbage					
Potato leaves					
Okra					
Egg plant					
Sugars					
Honey					
Sweets					
Drinks					
Beer					
Soda					
Milk /Milk products					
Milk					
Ice-cream					
Yogurt					
Skim milk (dry/liquid)					
Cheese					
Oils and fats					
Coconut					
Other foods					