KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

THE EFFECT OF NUTRITIONAL STATUS ON THE PREVALENCE OF CARDIOVASCULAR DISEASES AMONG DIABETIC PATIENTS

THIS DISSERTATION IS PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF MPhil. DEGREE IN HUMAN NUTRITION AND DIETETICS

BY

TUVOR ALICE

BSc. (HONS)

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DECLARATION

I declare that I have wholly undertaken the study reported herein under the supervision of Dr. Patricia Brown and Dr. Bernard Nkum and that except portions where references have been duly cited, this dissertation is the outcome of my research.

Tuvor Alice (20285935)	……	……..…….
(Student Name & ID)	Signature	Date
Certified By		
Dr. Patricia Brown	……	……..…….
(Supervisor)	Signature	Date
Certified By		
Dr. Bernard Nkum	……	……..…….
(Co-Supervisor)	Signature	Date
Certified By		
Dr. Hilary D. Zakpa	……	……..…….
(Head of Department)	Signature	Date

ABSTRACT

Diabetes mellitus is associated with increased incidence of cardiovascular disease (CVD). Poor nutritional status such as under- and over-nutrition accelerates the development of complications and reduces the longevity of life of diabetes patients. The study aimed to assess nutritional status, using anthropometric, biochemical, dietary indicators as well as unhealthy lifestyle factors and finding their association with cardiovascular diseases; mainly stroke, hypertension and heart failure. A cross sectional descriptive study was conducted among 145 diabetes patients selected from three hospitals in the Ashanti Region of Ghana. Nutritional status and lifestyle assessments were done using anthropometric, biochemical and dietary indicators of participants. Out of the participants, 76.6% were females. The mean age of respondents was 55.88 ± 12.75 S.D years. There was a significant association of age with cardiovascular diseases ($p<0.05$). The prevalence rates of cardiovascular diseases; hypertension, stroke and heart failure among the diabetic patients were 66.2%, 8.28% and 3.45%, respectively. The prevalence of overweight and obesity, assessed by BMI were 42.8% and 22.8%, respectively but there was no significant association of BMI with cardiovascular diseases ($p>0.05$). The prevalence of abdominal obesity, measured by waist circumference and waist to hip ratio were 61.38% and 65.5%, respectively and were significantly associated with cardiovascular diseases ($p<0.05$). Dyslipidemia among diabetes patients showed prevalence of hypercholesterolemia (47.58%), hypertriglyceridemia (55.9%), low HDL-C (35.2%) and high LDL-C levels (36.8%). Lipid profile showed that total cholesterol was not significantly associated with cardiovascular diseases, but TG, HDL-C and LDL-C levels were significantly associated with cardiovascular diseases. The study showed that 18.6% had high creatinine levels, but there was no significant association of creatinine levels with cardiovascular diseases ($p>0.05$). The study showed inadequate intake of fruits and vegetables and there was no significant association of fruit and vegetable intake with cardiovascular diseases ($p>0.05$). Majority of the respondents, 56.6% reported low salt intake, whilst 9.0% reported high salt intake. Salt intake showed significant association with cardiovascular diseases ($p<0.05$). The patients lifestyles showed low levels of physical activity, as 61.4% did not exercise, 91.0% diabetics had never smoked, 9.0% were ex-smokers, 33.8% were ex-drinkers, whilst 11.7% were current alcohol drinkers. The lack of exercise and smoking status had significant association with cardiovascular diseases ($p<0.05$) but alcohol consumption had no significant association with cardiovascular diseases ($p>0.05$). The study showed independent risk factors significantly associated with cardiovascular diseases incidence among diabetes patients included family history of hypertension with (odds ratio of 6.8), exercise (0.1), salt intake (0.1) and HDL-C level (0.2) with p-values < 0.05. In conclusion, the study has shown that family history of hypertension, moderate exercise, low salt intake and HDL-C level are significantly associated with cardiovascular diseases incidence.

ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ACCORD	Action to Control Cardiovascular Risk in Diabetes
ADA	American Diabetes Association
ADVANCE	Action in Diabetes and Vascular Disease
AGE(s)	Advanced glycated end product(s)
ANOVA	Analysis of Variance
BMI	Body Mass Index
BP	Blood Pressure
CVD	Cardiovascular disease
CVDs	Cardiovascular diseases
CHD	Coronary Heart Disease
CE	Cholesterol esterase
CO	Cholesterol oxidase
DASH	Dietary Approach to Stop Hypertension
DCCT	Diabetes Control and Complications Trial
DPP	Diabetes Prevention Program
DM	Diabetes Mellitus
DPPOS	Diabetes Prevention Program Outcomes Study
DSME	Diabetes Self-Management Education
DSMEP	Diabetes Self-Management Education Program
EDIC	Epidemiology of Diabetes Interventions and Complications
FPG	Fasting Plasma Glucose
GDM	Gestational diabetes
HbA1c	Hemoglobin A1c
HDL-C	High-density lipoprotein-Cholesterol

IDF	International Diabetes Federation
LDL-C	Low-Density Lipoproteins-Cholesterol
NCEP	National Cholesterol Education Program
NCHS	National Center for Health Statistics
NHLBI	National Heart, Lung, and Blood Institute
NCEP ATP III	National Cholesterol Education Programme Adult Treatment Panel III
OR	Odds Ratio
OPD	Out-Patient Department
PA	Physical Activity
POD	Peroxidase
SSA	Sub-Saharan Africa
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
TC	Total cholesterol
TG	Triglycerides
UKPDS	United Kingdom Prospective Diabetes Study
VEGF	Vascular endothelial growth factor
VLDL	Very low-density lipoprotein
WHO	World Health Organization
WC	Waist Circumference
WHR	Waist-to-Hip-Ratio

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CHAPTER ONE

1.1 Introduction

The increased burden of diabetes mellitus and cardiovascular diseases (CVDs) is the principal cause of death globally (WHO, 2011). Currently, diabetes and heart diseases affect many people in poor populations more than infectious diseases (WHO, 2008). Records from the International Diabetes Federation show that 4.8 million people died of the disease, and there were 371 million diagnosis in 2012 (International Diabetes Federation, Diabetes Atlas, 2012).

Diabetes was a rare disease in sub-Saharan Africa (SSA), but now 12.1 million adults are affected by the disease in this region, which is anticipated to rise to 23.9 million by 2030 (Sicree, 2009). The prevalence of diabetes in adults worldwide and in Africa, stands at 8.5% and 5.1% respectively (Whiting *et al.,* 2011). In Ghana, diabetes mellitus (DM) was reported in 1976 to be between 0.2 to 0.4% (Owusu, 1976). This prevalence has increased to 6.3% (Amoah *et al.*, 2002), with a prevalence of 3.9% in Greater Accra region (Vuvor *et al.,* 2011).

Diabetes mellitus (DM) is a disorder of metabolism, characterized by hyperglycemia, resulting from defects in insulin secretion, insulin action or both (Abou-Seif and Youssef, 2004).The defects lead to distinctive deficiency of insulin or its adequate function, resulting in disturbances in carbohydrate, lipid and protein metabolism, which manifest as prolonged hyperglycemia (Nair, 2007). There are two main types of diabetes type 1 and type 2. Type 1 diabetes, an insulin-dependent form of diabetes results from T cell-mediated autoimmune destruction of pancreatic beta cells (Kaufman *et al.*, 1993). In type 2 diabetes high blood glucose levels occurs due to the body's inefficient use of insulin and it is the more prevalent. Type 2 diabetes mellitus is characterized by a state of long-standing insulin resistance, compensatory hyperinsulinemia and varying degrees of elevated plasma glucose (Faghilimnai

et al., 2006). Apart from the two types of diabetes, there is also gestational diabetes, characterized by hyperglycemia, which is recognized firstly during pregnancy, with similar symptoms as in type 2 diabetes (WHO, 2008) and develops in about 2-5% of all pregnancies (ADA, 2002).

Diabetes mellitus is linked with complications including retinopathy, nephropathy and neuropathy. Elevated blood glucose levels in diabetics result in oxidative stress and endothelial damage which lead to diabetic complications (Giunti *et al.*, 2006). Cardiovascular disease (CVD) is the most common complication of Type 2 DM, with a 2 to 3 times occurrence in diabetics than in non-diabetics (Abraham, 2004). Studies by Bauters *et al.* (2003) and Thiam and co-workers have shown increased incidence of heart failure among diabetes patients. In a study in Nigeria among diabetes patients 58% had heart failure (Ola *et al.*, 2006). Diabetes mellitus plays a significant role in the etiology and development of cardiovascular diseases (Solang *et al.*, 1999).

Diabetes mellitus is characterized by hypermetabolism with metabolic and nutritional consequences (Bitz *et al.*, 2004). The metabolism of diabetics differs from the metabolism of people without it. In diabetes mellitus, metabolism of all the main food nutrients are altered (Nyarko *et al.*, 1997; Ryden *et al.*, 2007). Patients with type 2 diabetes (DMT2) suffer from macronutrient overnutrition, with increased fat stores but those with type 1 diabetes (DMT1) tend to be undernourished, by nutrient spillage through glycosuria (Ryden *et al.*, 2007).Nutrition plays a critical role in health status, as poor nutritional status accelerates development of complications and increases mortality rate of diabetic patients (Mitch, 1998).

Nutritional status can be assessed by several factors, including anthropometric, biochemical and dietary indicators, as well as lifestyle factors. The health and life expectancy of diabetes

patients are greatly affected by their nutritional status (Taubert *et al.*, 2007). In order to prevent the dreadful diabetic complications some diabetic patients control hyperglycemia, by restricting diet which sometimes leads to under-nutrition and health complications (Begum *et al.*, 2004). Alternatively, other patients are reluctant to consume the diet as prescribed by nutritional recommendations, hence become overweight, which is undoubtedly harmful to diabetic patients (Begum *et al.*, 2004).

Studies have clearly demonstrated links between obesity, arising from over-nutrition and many chronic diseases, including cardiovascular disease and diabetes (Taubert *et al.*, 2007). Obesity, hypertension and hyperlipidemia associated with over-nutrition increases the risk of stroke and heart diseases (Madonna *et al.*, 2004). Obesity, predominantly central obesity, is a risk factor for heart diseases, largely through insulin resistance and inflammation-mediated pathways (Madonna *et al.*, 2004). Insulin resistance is concomitant with increased lipolysis from the adipose tissue, resulting in the flux of fatty acids in different organs, including the liver, the heart and muscle (McGavock *et al.*, 2006). The high free fatty acids released causes insulin resistance, associated with a clustering of cardiovascular risk factors, including hypertension, dyslipidemia and abnormal fibrinolysis (Fagot-Campagna *et al*., 1998). It is known that insulin resistance causes DM and the processes by which this occurs has repercussions on CVD.

Chronic diseases have been linked with poor dietary intake for many years (Martin, 2006). Diabetes greatly increases the risk of heart disease and stroke even with well controlled glycemic levels (Candido *et al.*, 2003). Diabetes patients often develop cardiovascular diseases due to the prevalence of conditions such as high blood pressure (hypertension), dyslipidemia, smoking, obesity and lack of physical activity (Candido *et al.*, 2003).

These conditions above, such as poor diet and unhealthy lifestyle, recognized in diabetics have been related with significant risk factors of heart and chronic diseases (Arthur and John, 2000). Diet and nutrition maintained at optimum levels, prevent development of complications among diabetics. Hence, assessment of nutritional status indicators of diabetic patients is vital, as poor nutrition could contribute to the development cardiovascular diseases. This will offer valuable information for more comprehensive and intensive approach to diabetic patient care.

1.2 Aim of the Study

The study aimed to assess nutritional status as well as unhealthy lifestyle factors among diabetic patients and its association with prevalence of cardiovascular diseases mainly stroke, hypertension and heart failure.

The specific objectives were;

1. To assess the anthropometric data (body mass index, waist circumference and waist to hip ratio) of diabetic patients above 18 years with or without cardiovascular disease.
2. To determine the prevalence of dyslipidemia among diabetic patients.
3. To determine the creatinine levels of diabetic patients.
4. To assess the dietary intake of diabetic patients.
5. To assess the physical activity level and lifestyle of diabetic patients.
6. To determine the prevalence of cardiovascular diseases (hypertension, stroke and heart failure) among diabetic patients.

1.3 Study Hypothesis

The study hypothesis is that there is an association between nutritional status (anthropometric parameters, biochemical parameters, dietary intake) and other lifestyle factors of diabetics and the prevalence of cardiovascular diseases; namely, hypertension, stroke and heart failure.

1.4 Problem Statement

The upsurge in prevalence of diabetes in Ghana, especially among young adults has become a public health concern. In the 1950s, the prevalence of diabetes was estimated at less than 0.5% (Dodu, 1958), but increased to 6.3% in 2000 (Amoah *et al.*, 2002). The fact that many people between the ages of 15-59 years are affected by diabetes poses huge financial problem and threatens the economic stability of the nation (GNA report, 2013). Diabetes is a principal risk factor for cardiovascular disease (CVD). Studies have shown that diabetes increases the risk of CVD complications (Stamler *et al.*, 1993; APCSC, 2003). In a study among patients with heart failure in Ghana, 17% had diabetes (Amoah and Kallen, 2000).

Despite the rising prevalence of heart diseases among diabetic patients, the causative link between nutrition and lifestyle on CVD events is difficult to determine. The exposure to risk factors such as obesity, unhealthy lifestyle practices, hyperinsulinemia, elevated serum triglycerides and elevated total cholesterol among diabetics have been implicated in cardiovascular disease incidence (WHF, 2012). The extent to which these risk factors independently contribute to CVD development among diabetics is uncertain. Risk factors for cardiovascular disease in diabetics remain under-studied in sub-Sahara Africa (WHF, 2012).

Therefore, there is paucity of information on the magnitude of these risk factors among diabetic patients in the region. Hence evidence derived from other populations have been used to inform cardiovascular disease management and prevention among diabetics. This presents a faulty baseline, as differences in cultural, socioeconomic as well as genetic factors are not considered. This could lead to a misdiagnosis of the root cause of the disease and a diversion of efforts on other less important risk factors. Researchers continue to find risk factors associated with

various cardiovascular diseases among diabetics but the key problem that remains unanswered is, 'what risk factors, could cause predisposition of some diabetics to cardiovascular disease complications?

1.5 Justification

Efforts are required to fill the gaps in knowledge on diabetes and heart diseases in sub-Sahara Africa (SSA). As this will transform the current knowledge regarding interventions into useful strategies that will limit the burden of cardiovascular diseases among diabetes patients in this region. The indiscriminate application of recommendations derived from other countries to SSA populations may be unsuitable (Cobayashi *et al.*, 2010). Research is needed to improve knowledge on CVDs in Africa (Beaglehole *et al.,* 2010). The identification of dietary habits and lifestyle patterns among diabetics play an integral part in the management of the condition. Managing cardiovascular risk factors in diabetics will help reduce the progression of complications (American Diabetes Association, 2007).

For countless individuals with diabetes, the most important part of the treatment plan is determining what to eat. Therefore, from a preventive perspective, it would be useful to examine the association between nutritional status and the prevalence of the cardiovascular diseases among diabetics. This will provide data on the role of diet and lifestyle changes in preventing and controlling morbidity and premature mortality from diabetes and cardiovascular diseases.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews the work of other researchers in relation to the study. The chapter explains diabetes mellitus (DM), the types and complications of the disease, focusing on cardiovascular diseases. The development of cardiovascular disease in diabetes patients are also elaborated and relevant research findings on the prevalence of cardiovascular disease among diabetes patients are also reviewed. The chapter reviews research on the effect of nutritional indicators on cardiovascular disease among diabetes patients and the process by which nutritional factors such as anthropometric indicators, dietary indicators, biochemical indicators, and lifestyle factors such as smoking, alcohol consumption and physical activity, influence the incidence of cardiovascular diseases.

2.1 Diabetes Mellitus

Diabetes mellitus (DM) is no longer a rare disorder in the tropics, as its incidence is increasing in many places (Dodu, 1967). The disease is silent and several patients become aware only when its complications develop (Wee *et al.*, 2002). Diabetes mellitus is a chronic progressive metabolic disease, caused by elevated blood glucose levels in the blood, which may be the consequence of defect in insulin secretion, insulin action or a combination of both (American Diabetes Association, 2006; Hill, 2009). Diabetes is mainly classified as type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM), of which type 2 DM is the more prevalent (Alberti *et al.*, 1998).

2.2 Types of Diabetes Mellitus

Type 1 diabetes represents about 10% of all diabetes cases, affecting approximately 20 million people worldwide (Bierman, 2001). Type 1 diabetes mellitus is a condition characterized by a

lack of insulin production due to autoimmune destruction of pancreatic β-cells (Ammari, 2004). For type 1 diabetes diagnosis; autoantibodies to insulin and autoantibodies to the tyrosine phosphatases are the markers of the immune destruction (Keeling, 2012). At present, lifelong insulin therapy is the only management for this type of diabetes. Type 2 diabetes accounts for 90% of all diabetes cases worldwide and it is the most common (Kappala, 2012). Type 2 diabetes is a heterogeneous condition that results from genetic and environmental factors interaction (Litwak *et al.*, 2013). The main pathophysiological features, responsible for hyperglycemia associated with diabetes are inadequate insulin secretion and decreased insulin sensitivity (Kumar, 2002). Another type of diabetes is gestational diabetes mellitus, which is defined as any degree of glucose intolerance with onset or first recognition during pregnancy (World Health Organization, 2012).

2.3 Epidemiology of Diabetes and Cardiovascular Diseases

Globally in 2013, it was estimated that almost 382 million people suffered from diabetes, giving a prevalence of 8.3%, which increased to 9% in 2014 (Kengne *et al.*, 2005). A further 316 million with impaired glucose tolerance are at risk of the disease, set to reach 471 million by 2035. In sub-Saharan Africa (SSA), the overall DM prevalence is 4%, with estimated prevalence of 1% in rural areas, and ranges from 5% to 7% in urban sub-Saharan Africa (Kengne *et al.*, 2005). In urban Ghana, type 2 DM (DM2) affects at least, 6.3% of adults (Amoah *et al.*, 2002) and is associated with advanced age and obesity as 23% of adults are overweight (Amoah, 2003). In Ghana, currently 6.8% of adult admissions at the Korle-Bu Teaching Hospital are as a result of diabetes (Kengne *et al.*, 2005; Okertchiri, 2013). Risk factors including physical inactivity, dietary intake, ageing and obesity have contributed to high incidence of diabetes in Ghana (Amoah, 2003). Heart diseases deaths constitute 8.8% of all

deaths and 3.5% of all disability-adjusted life years (DALYs) in SSA (Krishnamurthi *et al.*, 2013).

Cardiovascular disease had been considered uncommon in SSA (Ntsekhe and Damasceno, 2013). However, both population- and hospital-based studies now show evidence for an increasing problem of cardiovascular disease in SSA, with diabetes mellitus as a main contributor (Ntsekhe and Damasceno, 2013). Several epidemiological studies have shown that CVD incidence in people with diabetes is two to four times greater than non-diabetics (Stamler *et al.*, 1993; APCSC, 2003). Diabetes mellitus plays a vital role in the pathogenesis of heart failure (Solang *et al.*, 1999). In a group of patients with heart failure in Nigeria, the fraction of those with diabetes was found to be 58% (Ola *et al.*, 2006). A study of patients with heart failure in Ghana, showed that 17% of those with coronary artery disease had diabetes (Amoah and Kallen, 2000).

2.4 Complications of Diabetes Mellitus

The source of concern with diabetes is the development of complications arising from the injurious effect of chronic hyperglycemia and its metabolic abnormalities (Fong *et al.*, 2004; Rotimi *et al.*, 2004). Most individuals with diabetes suffer complications (Agarwal *et al.*, 2013). Diabetes complications are divided into microvascular and macrovascular complications (Fröhlich-Reiterer & Borkenstein, 2010). Microvascular complications such as retinopathy, nephropathy and neuropathy are specific to DM, whereas macrovascular (coronary artery disease, peripheral arterial disease and stroke can occur in the absence of DM (FröhlichReiterer & Borkenstein, 2010). The proinflammatory microenvironment associated with hyperglycemia leads to the progression of microvascular complications in diabetes (Goh and Tooke, 2002).

High blood glucose levels results in the production of sorbitol, overproduction of superoxide, due to oxidative stress, overproduction of advanced glycation end-products and direct glucosemediated endothelial damage, which synergistically leads to progression of diabetic complications (Giunti *et al.*, 2006; Eid *et al.*, 2004). In diabetes mellitus, metabolism of all the main foodstuffs are altered. As a result of this, blood glucose concentration increases, cell utilization of glucose falls and utilization of fats and proteins increases (Guyton and Hall, 2006; Ismail *et al.*, 2000). These metabolic changes cause changes in endothelial permeability, extravascular protein deposition and coagulation, resulting in organ dysfunction (Giunti *et al.*, 2006).

2.5 Diabetic Retinopathy

The main microvascular complication of diabetes is retinopathy (Yadav *et al.*, 2008). Diabetic retinopathy (DR) is an ocular manifestation of diabetes in which there is damage to the retina, as a result of prolonged hyperglycemia (Mookiah *et al.*, 2015). There are two major types namely non proliferative diabetic retinopathy (NPDR) with no formation of new blood vessels and proliferative diabetic retinopathy (PDR) with formation new blood vessels in the retina (Harney, 2006). Loss of vision in diabetic retinopathy arises as a result of diabetic macular edema (DME) and proliferative diabetic retinopathy (Rema and Pradeepa, 2007).

Numerous processes have been linked with the development of retinopathy in diabetes patients. Increase in glucose levels leads to the build-up of sugar molecules; which causes sorbitol accumulation in cells (Gabbay, 2004). Sorbitol accumulation in the cells leads to osmotic stress which causes the development of diabetic microvascular complications, including diabetic retinopathy (Fong *et al.*, 2004). In diabetic retinopathy, there is the formation advanced glycolysated end products (AGEs) from free radical reactions and production of reactive

oxygen species (Fong *et al.*, 2004). Vascular endothelial growth factor (VEGF), growth hormone and transforming growth factor-β, contribute to the progress of diabetic retinopathy. However reduced VEGF levels is associated with delayed progression of retinopathy (Keenan *et al.*, 2007).

2.6 Diabetes Nephropathy

Diabetes can damage blood vessel clusters (glomeruli) in the kidney that filter wastes from the blood which could lead to the development of kidney failure or end-stage renal diseases (Gross *et al*., 2005). Diabetes causes damage in the kidney, resulting in a condition called diabetic nephropathy; characterized by proteinuria > 500 mg/24 hours in the setting of diabetes or albumin excretion of 30-299 mg/24 hours (Gross *et al*., 2005). Globally, most of the chronic renal conditions are as a result of diabetic nephropathy (Leung and Lam, 2000). Microalbuminuria is associated with progression of nephropathy which increases the risk of cardiovascular diseases in diabetics (Leung and Lam, 2000).

In Nigeria, a study by Alebiosu *et al.* (2003) among diabetic patients with persistent proteinuria showed a diabetic nephropathy prevalence of 28.4%. Ajayi *et al.* (2014) in another study on chronic kidney disease among newly diagnosed asymptomatic hypertensives and diabetics in Nigeria revealed a total of 242 (38.5%) had CKD stages 3a, 3b and 4. Study by Eghan *et al.* (2007) in Ghana, also showed that prevalence of microalbuminuria in patients with diabetes was 43%. Without intervention, diabetic patients with microalbuminuria typically progress to proteinuria and overt diabetic nephropathy. This progression occurs in both type 1 and type 2 diabetes (Gross *et al*., 2005).

2.7 Diabetic Neuropathy

Diabetic neuropathy is defined as damage to the peripheral nerve, primarily by high glucose levels (American Diabetes Association, 2007). Many individuals with diabetes will ultimately develop neuropathy, with some populations at risk of undergoing a lower extremity amputation (Abbott *et al.*, 2011). Diabetic neuropathy affects the peripheral nervous system, causing damage to the spinal cord and central nervous system (Singleton and Smith, 2012; Obrosova, 2009). Hyperglycemic-associated conditions such as accumulation of polyol, AGEs and oxidative stress are main causes of damage to the peripheral nerves (Boulton, 2005). Poor glycemic control and duration of diabetes are the major causes of neuropathy (King *et al.*, 1999).

2.8 Macrovascular Complications of Diabetes

Diabetes can lead to complications such as hypertension and atherosclerosis (Donaghue *et al.*, 2009). Conditions such as high blood pressure, elevated serum cholesterol and use of tobacco account for most of the macrovascular complications among diabetes patients (Dokken, 2008). The cells and extracellular matrix of the vascular wall are subject to disturbances mediated by oxidative stress, inflammatory responses and pathogenic mechanisms, and these are accelerated under hyperglycemic conditions (Dokken, 2008). Independent risk factors for vascular complications in diabetics are mostly dyslipidemia and poor glycemic control. Hypertensive heart disease is the cardiac damage related to chronic systemic arterial hypertension (Lavados *et al.*, 2005; WHO, 1997; Bronner *et al.*, 1995). Nowadays, hypertension prevalence among people >65 years of age, is roughly 30-40% in rural West Africa, 50% in semi-urban West Africa (de Ramirez *et al.*, 2010), 50-60% in South Africa and 30-50% in East Africa (de Ramirez *et al.*, 2010; Mathenge *et al.*, 2014).

2.9 Development of Cardiovascular Diseases in Diabetes

Cardiovascular disease is caused by disorders of the heart and blood vessels, and includes heart attacks, stroke, hypertension, peripheral artery disease, rheumatic heart disease, congenital heart disease and heart failure (WHO, 2014). The major causes of cardiovascular disease are tobacco use, physical inactivity, an unhealthy diet and harmful use of alcohol (WHO, 2014). An understanding of mechanisms underlying the development of CVD in patients with type 2 DM helps in the management of the disease. Atherosclerosis is most important process for cardiovascular disease development. Nutritional intake plays a major role in the development of cardiovascular disease, by influencing the onset of atherosclerosis progression to atherosclerotic plaque, which leads to thrombus formation (De Caterina *et al.*, 2006). CVD occurs through vascular abnormalities such as endothelial dysfunction and arterial stiffness, to the development of atherosclerotic lesions and eventually established end stage disease (Dzau and Braunwald, 1991).

Atherosclerosis is a complex process of numerous cell interactions that lead to “fatty streak” formation, known as atherosclerotic plaques (Ross, 1999). Extracellular deposition of lipids is followed by an inflammatory infiltrate of monocytes and T lymphocytes to form fatty streaks (Ross, 1999). Monocytes develop into macrophages and scavenge modified lipids to form foam cells (Woollard and Geissmann, 2010). The inflammatory infiltrate and foam cells secrete inflammatory mediators and produce reactive oxidative species, resulting in the migration and proliferation of vascular smooth muscle cells (Hansson, 2005). This process continues with further lipid deposition, inflammatory infiltration and vascular smooth muscle cell proliferation.

As the lesion develops, focal necrosis occurs at the centre; attracting further inflammatory cells and formation of fibrous tissue (Ross, 1999). As the lesion expands reduction in arterial blood flow occurs. The plaque may rupture with thrombus forming, leading to acute occlusion of the vessel (Ross, 1999). Multiple processes are involved in the initial development and progression of atherosclerotic plaques. Important processes in the development of atherosclerosis are endothelial dysfunction, oxidative stress, inflammation and increased arterial stiffness (Wilkinson and McEniery, 2004).

Vascular complications in diabetes mellitus are initiated, to a significant extent, by chronic hyperglycemia. High glucose concentration plays a central role in the progression of these complications, by altering gene expression of growth factors and cytokines, regulating vascular inflammation and activating macrophages and platelets (Hamilton *et al.*, 2004). High glucose mediates this by increasing the production of advanced glycation products, stimulating the polyol pathway, activating protein kinase C and enhancing the generation of reactive oxygen species (Hamilton *et al.*, 2004).

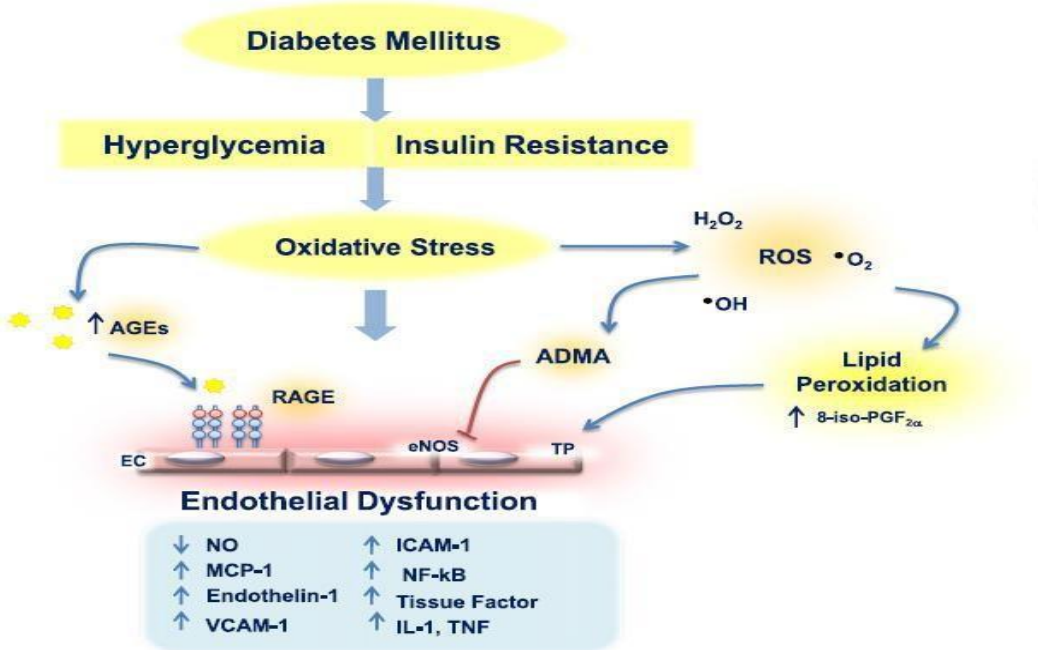

Figure 1: The Mechanism of Atherosclerosis in Diabetes Mellitus (Vazzana *et al.*, 2012).

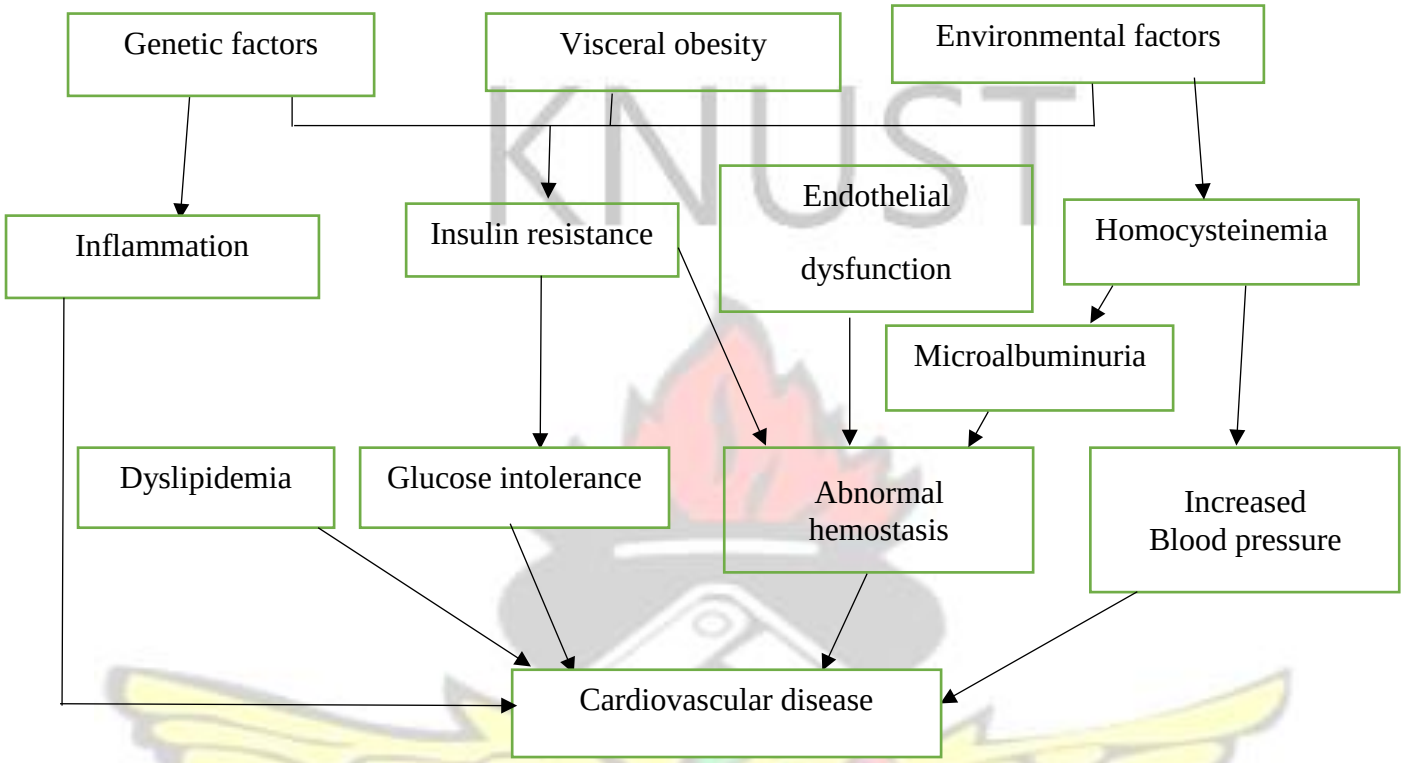

Figure 2: Type 2 diabetes mellitus and cardiovascular disease development (Martín-Timón *et al.*, 2014)

2.10 Nutritional status and Health

Nutrition is the foundation of healthy living, as it is the science of food and its relationship with health (Parks, 2009). The ability of the body to maintain metabolic integrity as influenced by diet and nutrient levels is termed nutritional status (Bender, 2005). Poor dietary intake is closely associated with chronic diseases (Martin, 2006). Adequate nutrition is necessary for cardiac function, muscle strength, immunity, wound healing and psychological well-being (Martin, 2006). Adequate nutrition is a diet that contains the right proportion of macronutrients and micronutrients that are essential for the body's physiological function. Malnutrition refers to either inadequate intake of nutrients, resulting in underweight and nutrient deficiency; or excess intake of nutrients from poor dietary habit, resulting in overweight and obesity (Arthur and

John, 2000). The development of heart diseases have at their core, atherosclerosis and hypertension, both of which are greatly affected by diet and can be approached, from a nutritional point of view (Getz and Reardon, 2007).

The risk factors of cardiovascular diseases are mostly poor dietary intake, including high salt and saturated fat intake and unhealthy lifestyle, entailing smoking, alcohol consumption and physical inactivity (Arthur and John, 2000). Over-nutrition increases the risk of stroke by accelerating the development of obesity, hypertension, hyperlipidemia and diabetes (Hamilton *et al.*, 2004). Hence, assessment of nutritional status of patients with diabetes is important because their nutritional status influences disease progression. The risk factors for CVD include tobacco use, dietary intake and physical inactivity, overweight, obesity and diverse childhood habits (Celermajer and Ayer, 2006; Dong *et al.*, 2004). Studies show that dietary intake, specifically energy-dense diets high in saturated fats and salt have contributed to an increase in CVD incidence in developing countries (Hu, 2008). Excessive and harmful intake of alcohol also clearly increases CVD risk (Lucas *et al.*, 2005).

2.11 Effect of Nutritional Status Indicators on Cardiovascular Diseases

2.11.1 Anthropometric Indicators (Generalized Obesity and Central Obesity)

2.11.2 Effect of BMI on Cardiovascular Diseases

Anthropometric measurements are vital in determining the risk factors for developing chronic diseases (Purnell *et al.*, 2000). The body mass index (BMI), an anthropometric indicator is a useful medical tool in determining whether an individual is underweight, normal weight, overweight or obese (Purnell *et al.*, 2000; Al-Sharafi and Gunaid, 2014). Body mass index (BMI) is a potential indicator of CVD risk factor, throughout the years (Cui *et al.*, 2005; Lobstein *et al.*, 2004). The incidence of cardiovascular diseases increases with body mass index (BMI), as well as with age (Dexter *et al.*, 2013). Researchers from the University of Oxford

have showed that the incidence of CHD increases with small incremental increases in BMI, hence for every 5 unit increase in BMI, CHD occurrence is increased by 23%, equivalent to the risk conferred by increase in age by 2.5 years (Dexter *et al.*, 2013). The risk for diabetes and hypertension have been shown by American Association of Clinical Endocrinologists (AACE) in 1998, to be about 2-fold in the mildly obese, 5-fold in moderately obese and 10fold in severely obese persons. The relationship between BMI and CVD mortality has been established; however, there is ambiguity about the specific types of CVD sturdily associated with excess weight (Lenz *et al.*, 2009; Pandeya *et al.*, 2012; Kurth *et al.*, 2005).

Increased body-mass index (BMI), is a well-documented risk for cardiovascular disease (Berrington de Gonzalez *et al.*, 2010; Czernichow *et al.*, 2011; Rahmanian *et al.*, 2014; Prospective Studies Collaboration, 2009). A number of epidemiological researches have established a relationship of body mass index (BMI) with cardiovascular disease. In a study by Bogers *et al.* (2007) overweight (BMI > 25 kg/m^2) and obesity were found to be associated with coronary heart disease (CHD). Observational studies undertaken in England and Asia have shown a relationship between body mass index (BMI) and ischemic heart disease (IHD) (Prospective Studies Collaboration, 2009; Asia Pacific Cohort Studies Collaboration, 2004). Consistently, a positive relationship has been shown between BMI and the risk of IHD and other cardiovascular diseases (Zheng *et al.*, 2011; Song *et al.*, 2004; Zhou *et al.*, 2008). The high incidence of CVDs are associated with risk factors such as generalized and abdominal obesity, determined by BMI and the waist circumference (WC), respectively (Grundy *et al.*, 2005; Lemieux *et al.*, 1994; Chen *et al.*, 2000; Ness-Abramof and Apovian, 2008). BMI correlates well with laboratory-based measures of adiposity in most clinical settings. However, BMI does not account for body fat distribution, body composition and size (World Health Organization, 1998).

2.11.3 Waist Circumference and Cardiovascular diseases

Visceral fat is a relevant risk factor for CVD, diabetes and other metabolic conditions (Goran *et al.*, 2003).Waist circumference (WC) is an appropriate measure of abdominal adipose tissue (Ross *et al.*, 1992; Han *et al.*, 1995) which correlates closely with BMI (Onat *et al.*, 1999) and total body fat (Lean *et al.*, 1996).

Increased adipose tissue in the visceral organs have been shown to be strongly connected with cardiovascular disease than BMI (Zhu *et al.*, 2002; World Health Organization, 2000). Central obesity correlates closely with excessive visceral fat, which is associated with insulin resistance, hypertriglyceridemia, highly atherogenic small LDL particles, and low HDL levels, features considered pro-atherogenic (Navab *et al.*, 2006; Dinarello, 2000; Ho *et al.* 2001). Hence, the heightened inflammatory state, coupled with more atherogenic lipid profile and hypertension leads to an excess of clinical cardiovascular diseases in individuals with visceral and central obesity, regardless of their weight (Navab *et al.*, 2006). The Health Professionals' Follow-up Study, among men older than 65 years revealed that those with highest WHR had a nearly 3-fold increased risk of CHD than those in the lowest WHR (Rimm *et al.*, 1995).

In men, several studies support significant risk associated with abdominal adiposity. Other studies also revealed that, the WHR was associated with increased risk of cardiovascular mortality. Fuchs *et al.* in 2005, found that WC and WHR, but not BMI, were associated with hypertension in all study groups, and Wessel *et al.* in 2004, found that WC and WHR, but not BMI, were associated with cardiovascular events.

Obesity is a nutritional disorder ensuing from disproportion between energy intake and energy expenditure, primarily due to physical inactivity (Boden, 1997). Factors contributing to obesity are heredity, over-eating, altered metabolism, defective or decreased thermogenesis, decreased physical activities without appropriate reduction in food intake and some prescribed medication (WHO/FAO, 2003). Obesity is a significant risk factor for cardiometabolic diseases, including diabetes, hypertension, dyslipidemia, and coronary heart disease (CHD) (World Health Organization, 1998). The fat distribution in the upper body is greatly linked with hypertension than with fat in the lower body (Lemieux *et al.,* 1996; Larsson *et al.,* 1984). The abdominal fat results in increased plasma non-esterified free fatty acids, through the release of non-esterified free fatty acids into the portal vein. This in turn, causes an excess hepatic synthesis of triacylglycerols, leading to insulin resistance and hyperinsulinemia (Maegawa, 2000).

Inflammation mediated pathways are the main mechanism through which obesity causes cardiovascular diseases. Insulin resistance associated with obesity causes increases inflammatory responses, through increased production of inflammatory mediators (Madonna *et al.,* 2004). This affects the production of several pro-inflammatory cytokines (adipokines) and hormones (Madonna *et al.*, 2004). Insulin resistance allows the initiation and perpetuation of vascular inflammation, through the increased gene expression of vascular cell adhesion molecule (VCAM-1), monocyte chemoattractant protein-1 (MCP-1) and macrophage colony stimulating factor, CD-40L (Madonna *et al.,* 2004). Monocyte migrates into the sub endothelial space, matures into a resident macrophage and takes up lipid, through scavenger receptors such as SR-A and CD-36, forming a foam cell (Jialal *et al.*, 2002). Later, smooth muscle cells migrate to the surface and form the fibrous cap of the lesion, and lastly, lipid-laden macrophages release matrix metalloproteinase, causing plaque rupture and unstable angina associated with development of cardiovascular diseases (Brownlee, 2001).

Atherosclerosis may proceed many years before the development of diabetes (Zavaroni *et al.*, 1989), through the formation of advanced glycation end products (Basta *et al.*, 2004), which can prolong an inflammatory response in the endothelium (Despres *et al.*, 1996). The atherogenesis begins as an endothelial cell dysfunction when various noxious attacks as dyslipidemia, hypertension, diabetes, smoking, *etc*. induce deficits of nitric oxide (NO) and prostacyclin (Boden, 1997; Grimble, 2000). Therefore, the increase in insulin production and plasma concentration that accompanies the compensated phase of insulin resistance increases atherogenic risk directly in obesity. Several studies have linked insulin resistance to systemic inflammation, as the result of increased concentrations of circulating free fatty acids (Boden, 1997; Grimble, 2002).

When hyperglycemia produces toxic effects on the endothelium, it propagates an inflammatory response in the endothelium (Cosentino and Egidy Assenza, 2004). There is evidence that obesity is associated with macrophage accumulation in the adipose tissue (Xu *et al.*, 2003). A recent study showed that the degree of infiltration of the adipose tissue by activated macrophages closely correlates with the adipocyte and that adipose-tissue-associated macrophage number is directly proportional to adiposity in humans (Weisberg *et al.*, 2003). If a positive energy balance is pro-inflammatory and increases cardiovascular disease risk, caloric restriction reduces inflammation, parallel to and likely reduces cardiovascular disease risk (Fontana *et al.*, 2004). The effect of caloric restriction protocols on risk factors for atherosclerosis has been evaluated, comparing individuals who had been restricting their food intake for 6 years and age-matched healthy individuals consuming a typical American diet (Fontana *et al.*, 2004).

The caloric restriction group had significantly lower body mass indices and percentages of body fat than the group consuming the American diet (Fontana *et al.*, 2004). Total serum cholesterol concentrations, LDL-cholesterol concentrations, triacylglycerol concentrations, fasting glucose, fasting insulin, C-reactive protein (CRP), platelet-derived growth factors A and B, and systolic and diastolic blood pressure were all markedly lower, and HDL cholesterol was higher, in the calorie restriction group than in the American diet group (Fontana *et al.*, 2007). None of the individuals in the caloric restriction group had evidence of atherosclerotic plaques (Fontana *et al.*, 2007). Very low plasma insulin concentrations and serum-derived platelet-derived growth factor A and B concentrations in the calorie restriction group suggest that caloric restriction results in a decreased stimulus for cell proliferation. Overweight, obesity and physical inactivity are major risk factors for stroke and important independent contributors to coronary heart disease, chronic heart failure, and other cardiovascular diseases (Murray and Lopez, 1997).

2.12 Dietary Factors

Dietary factors play a significant role in the development of cardiovascular disease (CVD) (Din, 2002; Hu & Willett, 2002), and dietary optimization is an important lifestyle intervention for the management of CVD and prevention (Ferrari *et al.*, 2004). Diet, a multi-component mixture of many nutrients, which may interact with one another and play a critical role in the development and prevention of cardiovascular disease (Mozaffarian *et al.*, 2011; Perrin *et al.*, 2002). The major environmental factors that lead to type II diabetes are sedentary lifestyle and over-nutrition, leading to obesity (Harris, 1991). According to World Heart Federation (2012), intake of diets low in saturated fat and rich in fruits and vegetables leads to a 73% reduction in CVDs.

Plasma cholesterol concentration increases with increased amount of cholesterol ingested daily (Arthur and John, 2000). Clear evidence exists that serum cholesterol correlates with the risk of CVDs and coronary death (Arthur and John, 2000). This can also be expressed by the relation between the percentage of daily energy intake from saturated fats, which correlates closely with serum cholesterol concentrations, and the degree of coronary artery disease. A high saturated fat diet increases blood cholesterol concentration by 15 to 25% (Arthur and John, 2000). When cholesterol is ingested, the rising concentration of cholesterol inhibits the most essential enzyme for endogenous synthesis of cholesterol, 3-hydroxy-3-methylglutaryl CoA reductase, thus providing an intrinsic feedback control system to prevent excessive increase in plasma cholesterol concentration (Arthur and John, 2000).

Studies by Kuller *et al.* (2006); Moore *et al.* (2011); Williams & Hoffman (2009) and Swain *et al.* (2008) on macro-and micronutrient diets in heart health, showed that the composition of the diet can be changed and still reach a reduction in a CVD risk by 16% to 21%. Further reduction of the risk was reached by substituting a part of the carbohydrates in the diet with either unsaturated fats or proteins (Swain *et al.*, 2008; Gross *et al.*, 2005).

2.12.1 Fruit and Vegetable Intake

Fruit and vegetables are important components of a healthy diet, and their adequate daily intake could help prevent most diseases, such as cardiovascular diseases and certain cancers (WHO/ FAO, 2003; Bazzano *et al.*, 2003). Fruit and vegetable consumption decreases CVD risk, through the beneficial combinations of micronutrients such as potassium, antioxidants, phytochemicals and fiber in these foods (Tribble and Nutrition Committee, 1999). A diet rich in fruit and vegetables reduces the risk of cardiovascular disease mortality by 15% (Leenders *et al.*, 2013). Furthermore, more than 4% of deaths due to cardiovascular disease could be

prevented by consuming more than 400 grams of fruit and vegetables a day (Leenders *et al.*, 2013). The American Heart Association and other national agencies recommend a diet that includes ≥5 servings of fruit and vegetables daily (US Department of Health and Human Services, 1995).

Research shows that fruit and vegetable intake help reduce cardiovascular diseases, through reduction of oxidation, inflammation and cell proliferation (Bonomo *et al.*, 2003; Genkinger *et al.*, 2004; Pereira *et al.*, 2004). Fruit and vegetable consumption prevents cardiovascular events by different mechanisms (Liu *et al.*, 2001; Padayatty *et al.*, 2003; Rasmussen *et al.*, 2006; Bonomo *et al.*, 2003; Genkinger *et al.*, 2004; Pereira *et al.*, 2004) such as reducing antioxidant stress, improving the plasma lipoprotein profile, lowering blood pressure, improving insulin sensitivity and hemostasis regulation (Van Duyn and Pivonka, 2000; Bazzano *et al.*,2003, Wannamethee *et al.*, 2006; Samman *et al.*,2003). Fruits possess antioxidant activity (i.e., scavenging free radicals, reducing oxidative stress, reducing LDL oxidation), cause induction of expression of hepatic LDL receptors, modulation of cholesterol synthesis, regulation of blood pressure, modify lipid profiles, prostanoid synthesis, and nitric oxide production, inhibition of cholesterol absorption, reduction of platelet aggregation and lowering serum Creactive protein and other inflammatory markers (Hertog *et al.*, 1997).

Research on the relationship between vegetable and fruit consumption on cardiovascular disease, established that there is a moderate inverse association between vegetable and fruit consumption on heart attack and stroke risk, with significantly higher, positive effects noted above five servings of vegetables and fruits per day (Murphy *et al.*, 2012; Hu *et al.*, 1999; Hu *et al.*, 2000). Evidence shows that adequate vegetables and fruit intake decrease the risk for obesity (WHO, 1990). Fruit and vegetable consumption contribute to increased feelings of

satiety (fullness), which can help in reducing overall energy intake, an important part of a weight management strategy (Azagba and Sharaf, 2011).

Several prospective studies have directly related fruit and vegetable intake to CVD (Ness and Powles, 1997). Several prospective studies have related higher fruit and vegetable intake to lower CVD mortality (Gaziano *et al.*, 1995) and morbidity (Joshipura *et al.*, 1999). A study of risk behaviors found that inadequate fruit and vegetable consumption has been associated with decreased life expectancy (Joshipura *et al.*, 1999). Nonetheless, there remains a low intake of fruits and vegetables globally (Hall *et al.*, 2009).

2.12.2 Sodium Intake

Reduction in sodium intake is linked with a decrease in blood pressure in hypertensive and normotensive individuals (Hooper *et al.*, 2004; Uzu *et al.*, 2006; Sacks *et al.*, 2001; Hoffmann and Cubeddu, 2007). On the contrary, high dietary sodium intake is linked with increased stroke incidence, and cardiovascular disease mortality (Hooper *et al.*, 2004; Ekinci *et al.*, 2011; Pimenta *et al.*, 2009). There was a systematic review by Hooper *et al.* (2004) on the effects of advice to reduce dietary salt in patients with elevated or normal BP (Hooper *et al.*, 2004). The review found no significant differences in cardiovascular morbidity between low sodium and control groups (Hooper *et al.*, 2004; Elliott *et al.*, 1996; Vedovato *et al.*, 2004; Provenzano *et al.*, 2014). A prospective study in Finland for over 13 years revealed in men, the risk of CHD and CVD was associated with higher sodium excretion in urine (Tuomilehto *et al.*, 2001; Meneton *et al.*, 2005). A Scottish study in women, found an association between sodium excretion and the incidence of coronary events (Tunstall-Pedoe *et al.*, 1997). Among obese people, a high salt intake is associated with increased risk of CVDs. A prospective large study by He *et al.* found that in participants who were overweight, sodium intake was associated with

increased frequency of stroke and mortality from CHD and CVD (He *et al.*, 1999; Huang *et al.*, 1998).

2.13 Biochemical Risk Factors

2.13.1 Dyslipidemia

The most important risk factor for complications in diabetes is dyslipidemia, the second most prevalent cardiovascular risk factor globally (Tekes-Manova *et al.*, 2005; Goldberg, 2001; Krauss, 2004). Dyslipidemia is defined by the presence of one or more than one abnormal serum lipid concentration, according to United State National Cholesterol Education Program Adult Treatment Panel (NCEP-ATP) III guideline (Safeer and Ugalat, 2002). The reasons for the management of lipoprotein abnormalities in diabetic patients are to prevent pancreatitis, due to severe hypertriglyceridemia and to reduce the risk of macrovascular complications (Kako *et al.*, 2002; Jayarama *et al.*, 2012; Haffner *et al.*, 1998).

Dyslipidemia contributes to the development of arteriosclerosis, which progresses even faster in the presence of hypertension and diabetes mellitus (Dunn, 1990). In type 2 diabetes mellitus (T2DM), the most common abnormal lipid pattern is a combination of elevated TG levels and decreased HDL cholesterol (Dunn, 1990). The functions of HDL particles that lead to cardioprotective effects, include promotion of cellular cholesterol efflux and direct antioxidative and anti-inflammatory properties (Lamarche *et al.*, 1996). In the Quebec Cardiovascular Study, HDL_2 particles contributed to the cardioprotective effects of high HDL cholesterol levels, more than HDL_3 particles (Assmann and Schulte, 1992; Manninen *et al.*, 1992).

Diabetic dyslipidemia is linked with quantitative and qualitative lipid abnormalities due to increased hepatic lipase and decreased lipoprotein lipase activity, resulting in decrease in

VLDL clearance (Arora *et al.*, 2007). A study conducted in Saudi Arabia, on lipid profile of diabetic patients, showed the prevalence of dyslipidemia among diabetic with high risk levels of TC, TG, LDL-C and HDL-C (Habib, 2006; Marcus, 2001; Lehto *et al.*, 1997). A prospective study has found that plasma triglyceride level is a risk factor for cardiovascular disease in men and women, independent of high-density lipoprotein cholesterol level (Hokanson and Austin, 1996).

The Strong Heart Study, among American Indian patients with diabetes showed that increased LDL-C level by 10 mg/dl, increased the risk of cardiovascular disease by 12% (Howard *et al.*, 2000). Many prospective epidemiologic studies have reported a positive relationship between serum triglyceride levels and incidence of coronary heart disease, especially in patients with diabetes (Tseng *et al.*, 2006).

2.14 Unhealthy Lifestyle and Cardiovascular Disease Risk in Diabetes

2.14.1 Smoking

Smoking is connected with weakening in metabolic control in diabetic patients (Bott *et al.*, 1994) which is linked with an increased risk for development of cardiovascular complications (Chase *et al.*, 1991). The mechanism by which smoking causes cardiovascular disease is through impaired insulin sensitivity; due to compromised beta-cell function and hemodynamic dysregulation in capillary vascular bed (Kirschbaum *et al.*, 1992; Wellman and Kamp, 2008). Furthermore, smoking causes bronchitis and pulmonary infections which increase inflammatory markers associated with impaired insulin sensitivity (Kirschbaum *et al.*, 1992; Peters *et al.*, 2008). Direct effects of tobacco smoking are lipotoxicity, resulting from increased triglyceride levels, hypercortisolemia, increase in abdominal fat tissue and elevated sympathetic nervous activation (Kirschbaum *et al.*, 1992).

Smoking leads to nicotine inhalation which results in increase circulating levels of insulinantagonistic hormones (growth hormone, catecholamines and cortisol) and negatively affects the autonomic nervous system (Kirschbaum *et al.*, 1992; Lucini *et al.*, 1996). Nicotine, by these mechanisms, decreases insulin sensitivity, which directly or indirectly leads to the development of cardiovascular disease (Bergman and Ader, 2000; Kirschbaum *et al.,* 1992; Lucini *et al.*,

1996). Also, smoking increases circulating free fatty acid levels (Kershbaum and Bellet, 1996; Bott *et al.,* 1994), and causes an additional negative effect on the insulin-mediated glucose uptake. In a study of patients with diabetes, followed in the UKPDS, smoking was shown to increase the risk of CHD (Turner *et al.,* 1998; Morrish *et al.,* 1991). The expected relative risk incidence of myocardial infarction attributable to smoking was 1.350 (95%CI: 1.11-1.59). This reveals that smoking is an independent and significant risk factor for stroke (Kothari *et al.*, 2002) and peripheral vascular disease (Adler, 2002). A study in 1997 by Chaturvedi *et al.* revealed that smoking cessation decreases mortality risk in diabetes patients.

2.14.2 Alcohol Intake

Alcohol consumption is a major risk factor for diseases (Alwan, 2011). Globally, alcohol causes more deaths than deaths by infectious diseases (Alwan, 2011). Injuries and cardiovascular diseases are the major complications of excessive alcohol (Alwan, 2011). Globally, alcohol causes more deaths in males than in females (Alwan, 2011). The electrical movement of the heart is altered due to excessive alcohol consumption which leads to ventricular fibrillation and cardiac arrest (Cairns *et al.*, 1984; Cooper *et al.*, 2004). Furthermore, long-term excessive alcohol intake weakens the heart muscle and makes it less efficient, through dilated cardiomyopathy and damage in myocardial tissue through oxidative stress (Mukamal *et al.*, 2010).

A study by Ormel *et al.* (2007) in Nigerians found that patients who were alcohol abusers were more likely to have heart disease, compared to non-alcohol abusers. Similarly, in Nigerian patients with heart failure in a teaching hospital in Jos, more than 24% of heart failure patients reported regular alcohol intake (Laabes *et al.*, 2008; Moeini *et al*., 2011). Puepet and Ohwovoriole (2008) conducted a study to identify risk factors for type 2 diabetes in Jos, Nigeria, and found that alcohol consumption was highly prevalent among the diabetic patients, In a study in Kenya, it was found that excess alcohol consumption was related to increased likelihood of glucose intolerance in men (Christensen *et al*., 2009). In a prospective cohort study among Cameroonians, alcohol consumption was related to increased likelihood of cardiovascular death (Kengne and Awah, 2009). Alcohol consumption has been associated with a lower risk of CVD in individuals who are light to moderate drinkers (Mukamal *et al.*, 2010; Facchini *et al.*, 1994; Kiechl *et al.*, 1996). People who refrain from alcohol show a higher death rate from CVD than do light drinkers (up to three drinks per day), but heavy drinkers (more than three drinks per day) die more frequently of CVD than do light drinkers (Lands and Zakhari, 1990). Excessive alcohol drinking offsets the benefits of alcohol and has been connected with hypertension, hemorrhagic stroke, and cardiomyopathy (Lands and Zakhari, 1990).

The risk of hypertension is reduced when excessive drinkers decreased their alcohol intake (Lands and Zakhari, 1990; Mahan and Escott-Stump, 2008). Significant association between excessive alcohol consumption and hypertension was observed among females in Munich by Cairns *et al.* (1984). Binge drinking has been associated with increased risk of cerebral hemorrhage and ischemic stroke (Lands and Zakhari, 1990).

2.14.3 Physical Inactivity

According to World Health Organization (2012), an adequate amount of physical activity decreases the risk of heart diseases (WHO, 2012). The terms physical activity and exercise are frequently used interchangeably. Exercise is a sub-category of physical activity (Caspersen *et al.*, 1991). While physical activity is any movement which is created by skeletal muscles, exercise is always planned, recurring physical activity that has a structure and is undertaken with the purpose of improving the physical fitness (Caspersen *et al.*, 1991).

According to the American Diabetes Association, physical activity helps control blood glucose levels, lowers blood pressure, improves blood fats, as well as reduce the amount of insulin doses or diabetic pills after losing weight (American Diabetes Association, 2004). It also helps maintain the weight a person loses and lowers the risk of health problems, hence helps sustain a healthy life (American Diabetes Association, 2007). Regular physical exercise reduces the risk of cardiovascular diseases (Swartz *et al.*, 2003, Murphy *et al.*, 2002). This evidence is subject to other lifestyle changes that take place together with exercise (for example stopping smoking, a balanced diet, etc. (Shephard and Balady, 1999; Powell *et al.*, 1987).

Patients with DM have a reduced capacity to exercise, due to ageing, overweight and the presence of left ventricular dysfunction (Fang *et al.*, 2005; Gregg *et al.*, 2000). Exercise improves insulin sensitivity in diabetic patients in the same way as it does in non-diabetic patients (Kirwan *et al.*, 2009; Winnick *et al.*, 2008). Patients with diabetes have greater insulin resistance, which improves with physical exercise (Richards *et al.*, 2010; Le Brasseur and Ruderman, 2005). Increased physical activity achieves higher mitochondrial enzyme activity and increases insulin sensitivity (Richards *et al.*, 2010). Multiple studies have shown physical

exercise improves cardiovascular risk factors (dyslipidemia, hypertension and body composition) in patients with DM (Chudyk and Petrella, 2011).

Different kinds of physical activities do not exert the same influence on CVD risk. Aerobic exercise only or combined with resistance exercise improves glycemic control, BP, the amount of TGs and WC (Sluik *et al.*, 2012). In prospective cohort studies, exercise promoted reduced cardiovascular mortality in patients with T2DM (Sluik *et al.*, 2012). Results from the Nurses' Health Study by Hu *et al.* (2001) reported that women with T2DM who exercised for at least 4 h per week had a 40% lower risk of developing heart diseases, compared to those who did not. This risk improvement remained after adjustments for smoking, BMI and other cardiovascular risk factors. High blood pressure, cholesterol levels, obesity, diabetes, and lack of physical activity can all be positively affected by a regular exercise program (Jenna and Barry, 2012).

Regular exercise improves glycemic control in all types of diabetes (Goodpaster *et al.*, 2010). Regular exercise can reduce free fatty acid load to liver, the main cause of insulin resistance in obesity and thereby reduce hepatic insulin resistance (Haus *et al.*, 2011). Exercise recommended is moderate exercise for 30 minutes a day or moderate physical activity like brisk walking at least 150 minutes per week (Tuomilehto *et al.*, 2001).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Design

This study was a descriptive comparative cross-sectional study, carried out from June to November, 2015.

3.2 Study Site

The study was conducted at three sites; St. Michael's Hospital, located at Jachie-Pramso in the Bosomtwe district, Kumasi South Hospital, located at Agogo in Kumasi, and Aninwah Medical Centre located at Emena in Kumasi; all three study sites are located in the Ashanti Region of Ghana.

3.3 Study Population and Sample Size

Diabetic patients who visited the St. Michael's Hospital, Kumasi South Hospital and Emena Hospital were used for the study. One hundred and forty five diabetes, patients made up of 97 who had cardiovascular disease; mainly stroke, hypertension and heart failure and 48 without cardiovascular disease, were used for the study. The minimum sample size of 70 diabetic patients used, based on calculations using the following variables**:** The proportion exposed in the control group 17%, at 80% power, $Z_{\square}$=0.84. At 0.05 significance level, $Z_{\square}$=1.96, Odds Ratio (0R)=3 r=1 EpiTools (*Epitable calculator*, AusVet, power at 80%) (http://epitools.ausvet.com.au/content.php?page=casecontrolSS&P1=0.17&RR=3&Conf=0.95& Power=0.8)

$$n\square(rr\square 1)(\bar{p})(1\square(p\bar{p}_1)(\square Zp_{\square 2})\square_2 Z_{\square/2})^2$$

$$n\square(rr\square 1)(\bar{p})(1\square(p\bar{p}_1)(\square Zp_{\square 2})\square_2 Z_{\square/2})^2$$

(Charan and Biswas, 2013; Naing, 2003).

To get proportion of cases exposed:

$$p_{caseexp} = \frac{ORp_{controlsexp}}{p_{controlsexp}(OR-1)+1}$$

$$p_{caseexp} = \frac{3.0(.17)}{(.17)(3.0-1)+1}$$

$$0.51/0.34 = 0.38$$

Average = (0.38+0.17)/ 2= 0.275

$$n = 2\frac{(.275)(1-(.38.275)}{.17)}(.84^2-1.96)^2 = 70$$

3.4 Inclusion and Exclusion Criteria

3.4.1 Inclusion Criteria for Control Participants

- Type1 and 2 diabetes patients without any cardiovascular disease
- Male or female diabetics above 18 years
- Willingness to take part in the study

3.4.2 Inclusion Criteria for Case Participants

- Type1 and 2 diabetes patients
- Diabetics above 18yrs with cardiovascular disease such as hypertension, heart failure and stroke diagnosed by a physician.
- Willingness to take part in the study

3.5 Exclusion Criteria for Participants

- Gestational diabetes patients
- Diabetes patients below 18yrs

- Diabetics with other cardiovascular complications different from stroke, hypertension and heart failure.

3.6 Sampling Procedure

Participants were recruited by random sampling in all three hospitals for patients who were willing to participate in the study.

3.7 Questionnaire-Based Data Collection

A structured questionnaire was used to collect information from participants. The questionnaire was divided into the five sections: A: Demographic information (age, gender, place of residence, level of education and employment status).

B: dietary habits

C: physical activity

D: family and medical history, co-morbidities and

E: lifestyle of respondents.

3.8 Pre-testing of Questionnaire

The questionnaire used for data collection was piloted on ten participants at the Diabetes center at the St. Michael's Hospital. This was done to ensure that all relevant information needed for this research were captured appropriately. The pre-test results revealed that the data capturing sheets needed some minor modifications. Hence, some questions were eliminated and those which were not clear were modified

3.9 Anthropometric Variables

Anthropometry is the measurement of body size, weight, and proportions (Lee and Nieman, 2003). Anthropometric measurements made included weight, height, waist circumference, hip

circumference and waist-to-hip ratio. The measurements were compared to reference standards to assess risk for various diseases (Laquatra, 2004).

3.9.1 Body Mass Index

The BMI was calculated mathematically from the height and weight measures (Tsigos *et al.*, 2008). BMI = weight (kg) / Height (m^2). The values were used to classify BMI into categories, based on the World Health Organization criteria (2012).

3.9.2 Weight Measurement

Weight was measured with an Omron Body Composition Monitor scale (BF- 506, Omron Healthcare, Inc., Vernon Hills, IL, USA), to the nearest 0.1kg, with subjects in light clothing and standing erect. Each subject stood still, with weight evenly distributed on both feet, with no additional support, while the reading was taken (Heymsfield *et al.*, 1999).

3.9.3 Height Measurement

Height was measured with a portable Seca stadiometer (Hamburg, Germany) to the nearest 0.1 centimeter. Subjects were made to stand upright on a base plate without shoes, with their head and back straight, feet together and heels touching the back of the plate. The head plate was lowered to touch the top of the head and height noted (Heymsfield *et al.*, 1999).

3.9.4 Waist and Hip Circumference

Waist circumference was measured with a Gulick II springloaded measuring tape (Gay Mills, WI) midway between the inferior angle of the ribs and the suprailiac crest and recorded to the nearest 0.1cm (Hammond, 2000). Hip circumference was measured with a Gulick II springloaded measuring tape (Gay Mills, WI) around the point with the maximum circumference of the buttocks and recorded to the nearest 0.1cm (Hammond, 2000).

Waist to hip ratio (WHR) was calculated by dividing the waist circumference by the hip circumference. All measurements were taken with participants dressed in light clothing (Sizer & Whitney, 2003).

3.10 Dietary Intake

Dietary intake was assessed using a food-frequency questionnaire and 24-hour dietary recall methods, to determine dietary intake and habits over the past year. Food models and household measurements were used in portion size estimation. Handy measures such as ladles, spoons (dessert and tea spoons), milk tins, sardine tins and calibrated cups were also used to help collect information on meal quantities.

3.11 Cardiovascular Disease Diagnosis

The cardiovascular diseases used were stroke, hypertension and heart failure. The diagnosis of cardiovascular disease was based on the American Heart Association criteria and classification, as diagnosed by a physician. Hypertension was defined using the World Health Organization and International Society of Hypertension criteria (WHO and ISH, 2003) as systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg.

3.12 Blood Pressure Measurement

Blood pressure (systolic blood pressure) and (diastolic blood pressure) were obtained twice with subjects in sitting position, using digital sphygmomanometer (an Omron Blood Pressure Monitor model BP 785). Three measurements were taken, within a minute interval, in the right arm and the average of the last 2 readings used.

3.13 Biochemical Indicators Measurements

The biochemical measurements made were fasting blood glucose levels (FBG), serum total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) levels and serum creatinine.

3.13.1 Blood Collection and Handling

Five millimeter fasting blood samples (overnight fast between 8-12 hours) were drawn from the antecubital vein on the anterior forearm (the side within the fold of the elbow) into gel separator tubes (BD, Plymouth, PL6 7BP, UK) for total cholesterol, HDL, LDL and TG. Blood samples were taken from participants before 9:00 hours in the morning. Fluoridated blood samples were kept on ice, prior to centrifugation within 15 minutes of blood draw. The fluoridated blood was centrifuged (Zentrifugen, D-78532, Tuttlingen, Germany) at 3000 rpm for 5 minutes to separate the serum from the deposit. All analysers were calibrated before the start of the analysis. Results which were flagged as high or low were repeated to verify their reproducibility.

3.13.2 Fasting Blood Glucose Measurement

The fasting blood glucose (FBG) was measured using the ONETOUCH glucometer (Serial number: DCFVWB3E), using the procedures below. Fasting blood glucose (FBG) reading was measured and recorded for each participant.

1. The glucometer was prepared for the test by switching it on and ensuring that it was working properly
2. The researcher then washed and sanitized hands and wore the laboratory hand gloves
3. The test strip was then inserted into the slot provided on the glucometer
4. Alcohol was poured on a cotton ball/cotton wool till soaked with alcohol

5. The side of the thumb where the blood sample was to be drawn was then cleaned with the cotton wool soaked with alcohol
6. When the glucometer indicated that sample could be dropped on the strip, the researcher used the lancet pricker to prick appropriately at the cleaned area where sample was to be taken
7. A drop of blood was then placed directly onto the test strip inserted into the glucometer
8. The researcher then waited for the reading to appear in few seconds
9. The researcher then read and recorded the fasting blood glucose of the patient.

3.13.3 Lipid Profile: (Triglycerides, HDL, LDL and total cholesterol)

The lipid profile - total cholesterol (TC), high density lipoprotein (HDL) and triglycerides (TG) of each patient was measured with Selectra Junior Auto Analyzer (Vital Scientific, N.V. Netherlands) and low density lipoprotein (LDL) calculated by same analyzer. 10µl of serum was pipetted into the auto analyzer at internal temperature of 37 C and an incubation period of 10 minutes, after which readings for each of the lipid parameters were displayed and recorded.

3.13.4 Serum Creatinine

Serum creatinine was determined with a standard autoanalyzer RA-XT (Bayer, Elkhart, IN). 10µl of serum was pipetted into the auto analyzer at internal temperature of 37 C and an incubation period of 10 minute, after which readings for the creatinine were displayed and recorded.

3.14 Operational Definition of Terms

Diabetes was diagnosed when fasting blood glucose was 126 mg/dl (6.40 mmol/l) and higher. (The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2003). BMI was categorized according to the WHO (Laquatra, 2004):

Underweight-BMI less than 18.5 kg/m^2

Normal BMI-18.5 to 24.9 kg/m^2

Overweight BMI-25.0 to 29.9 kg/m^2

Obesity BMI-30.0 kg/m^2 and

Obese class I: 30.0 – 34.9 kg/m^2, Obese class: II 35.0 – 39.9 kg/m^2, Obese class III: > 40 kg/m^2. Using the waist circumference participants were classified as follows: normal: WC < 80 cm, overweight: WC of 80 - 87.9 cm and obese WC ≥ 88 cm for females (NHLBI Obesity Education Initiative, 2000). Men with waist circumference (WC) < 94 cm, 94–101.9 cm and ≥102 cm were classified as normal, overweight and obese respectively. Men with WHR < 0.90, 0.90 – 0.99 and ≥ 1 and women with WHR < 0.80, 0.80–0.84 and ≥ 0.85 were classified as normal weight, overweight and obese respectively (NHLBI Obesity Education Initiative, 2000).

Hypertension was defined using the World Health Organization and International Society of Hypertension criteria (WHO and ISH, 2003) as systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg. Raised total cholesterol defined as total cholesterol ≥ 6.50 mmol/L. High serum triglycerides defined as serum triglycerides ≥ 1.70 mmol/L. High serum LDL-C defined as LDL–C ≥ 4.90 mmol/L. Low serum HDL-C defined as with HDL- Cholesterol < 1.55 mmol/L (Dyslipidemia was diagnosed according to NCEP ATP III). High creatinine levels defined as creatinine ≥ 120 μmol/l.

Insufficient physical activity, defined as attaining less than 150 minutes of moderate- intensity physical activity (e.g slow dancing, brisk walking and table tennis) per week or less than 75 mins of vigorous–intensity physical activity (e.g. running and football) per week (Bull *et al.*, 2009). Diabetics currently smoking any tobacco product includes both daily and non-daily or occasional smoking.

3.15 Ethical Considerations

This study was performed under a protocol that was reviewed and approved by the Committee on Human Research, Publications and Ethics (CHRPE), School of Medical Sciences, Kwame Nkrumah University of Science & Technology (KNUST), Kumasi. Letters were sent to the St. Michael's Hospital, Kumasi South Hospital and Emena Hospital to seek permission, which was duly granted. All the prospective participants in this study were informed about the study. The purpose of the study was thoroughly explained to the participants to select those willing to participate and those who declined to participate in the study were excluded. The patients who met the inclusion criteria and were willing to partake in the study were made to sign or thumbprint on the consent forms before they were enrolled to take part in the study.

3.16 Statistical Analysis

Anthropometric, biochemical, dietary, demographic and socio-economic data were analysed by using Statistical Package for Social Sciences (SPSS), version 20. Continuous variables were expressed as mean and standard deviation, whereas categorical variables were expressed as percentages. The significance of the differences in the mean values between cases and controls for normally distributed parameters were determined using the independent samples t-test for continuous variables and Chi-square test for categorical variables at 95% confidence level.

Binary logistic regression model was used to test for independent association with CVDs. Pvalues <0.05 were reckoned as statistically significant.

CHAPTER FOUR

RESULTS

Introduction

Data were obtained from 145 diabetic patients in three different hospitals in the Ashanti region and analyzed.

4.1 Demographic Characteristics of Respondents

Tables 4.1 and 4.2 show the socio-demographic characteristics of respondents. A total of 145 known diabetic patients were recruited. Out of the participants, 76.6% were females. More female respondents (48.3%), had cardiovascular diseases. However, based on gender, the difference between diabetics with and without CVDs showed no statistical significance (p=0.076) (Table 4.2). More female respondents were overweight and obese (31.7% and 17.9%) respectively, with no significant gender differences in BMI (p=0.930) (Table 4.3).

The overall mean (±SD) age was 55.88 ± 12.75, ranging from 26-93 years. Tables 4.2 shows more than half of the patients (53.1%) were in the age group 40-60 years, and diabetics with age above 40 years had significantly higher prevalence of CVDs (p=0.000).

On educational attainment Tables 4.1 shows majority of the diabetics (69.0%), were Junior High School leavers. From Table 4.2, diabetics with CVDs had higher percentage of the lowest level of education, while having the lower percentages of secondary and tertiary education. However, the difference in educational status between the diabetics with and without CVDs was not significant (p=0.277).

On employment status, more diabetics with CVDs were unemployed, compared to those without CVDs. The difference in employment status showed significance (p= 0.039).

On income status, diabetics with CVDs had higher proportion of respondents with low income status but lower percentage of those with high income status, with significant differences in the income level (p=0.021). The majority of the respondents, 85.5% were of Akan ethnicity. However, ethnic differences between diabetics with and without CVDs showed no significant differences (p=0.649) (Table 4.2).

4.2 Cardiovascular Diseases

Out of the diabetic respondents, 66.9% reported suffering from at least one of the cardiovascular diseases of study (hypertension, stroke or heart failure), whilst 33.1% of the respondents had no incidence of cardiovascular disease. From Table 4.4, hypertension was the most common cardiovascular disease. According to Table 4.5, more female diabetics had CVDs but the difference was not statistically significant (p=0.076).

4.3 Anthropometric and Blood Pressure Data of Respondents

The anthropometric data and blood pressure of participants are presented in Tables 4.6 and 4.7. The mean BMI of respondents with CVDs and those without CVDs were similar. From Table 4.6, diabetics who were overweight and obese had higher prevalence of CVDs. However, the difference in BMI between the diabetics with and without cardiovascular disease was not significant (p=0.89).

More diabetics with CVDs had higher WC and WHR than those without CVDs. Based on WC, diabetics with CVDs had significantly higher means values (p=0.000). Additionally, waist to hip ratio of diabetics with CVDs was significantly higher (p=0.005) than those without CVDs (Table 4.7).

4.4 Blood Pressure of Respondents

Generally, both systolic and diastolic blood pressure were higher in diabetics with CVDs than those without CVDs with significant statistical differences (p=0.00) (Table 4.7).

Table 4.1 Demographic Characteristics of All Diabetic Respondents

Variable	Diabetic Respondents (N=145) No. (%)
Gender	
Male	34 (23.3)
Female	111 (76.7)
Age (years)	
Below 40 Years	15 (10.3)
Between 40 - 60 Years	77 (53.1)
Above 60 Years	53 (36.6)
Educational Level Junior	
High School	100(69.0)
SHS/A Level completed	24(16.6)
Tertiary completed	21(14.4)
Income Level	
Low income	104 (71.7)
Middle income	34 (23.45)
High income level	7 (4.8)
Employment Status	
Employed	76 (52.4)
Unemployed	69 (47.6)
Marital Status	
Married	77 (53.1)
Single/divorced/separated	33 (22.8)
Widowed	35 (24.1)
Ethnicity	
Akan	124 (85.5)
Ewe	7 (4.8)
Ga	5 (3.4)
Hausa/Gonja/Dagbani	9 (6.2)

Table 4.2 Comparison of Demographic Characteristics of Respondents with and without CVDs

Variable	Diabetics without CVD (N= 48) No. (%)	Diabetics with CVD (N= 97) No. (%)	Total (N=145)	P-Value
Gender				**0.076**
Male	7 (4.8)	27 (18.6)	34 (23.3)	
Female	41 (28.3)	70 (48.3)	111 (76.7)	
Age				**0.000**
Below 40 years	12 (8.3)	3 (2.06)	15 (10.3)	
40-60 years	27 (18.6)	50 (34.5)	77 (53.1)	
Above 60 years	9 (6.2)	44 (30.34)	53 (36.6)	
Educational Status				**0.277**
JHS Level	34(23.4)	66 (45.5)	100(69.0)	
SSS/A Level	5 (3.5)	19 (13.1)	24(16.6)	
Tertiary Level	9 (6.2)	12 (8.3)	21(14.5)	
Employment Status				**0.039**
Employed	31 (21.4)	45 (31.0)	76(52.4)	
Unemployed	17 (11.7)	52 (35.9)	69(47.6)	
Marital Status				**0.0097**
Married	17 (11.7)	60 (41.4)	77 (53.10)	
Single/divorced/separated	16 (11.0)	17 (11.7)	33(22.76)	
Widowed	15 (10.3)	20 (13.9)	35(24.13)	
Income Level				**0.021**
Low –Income	28 (19.4)	75 (51.7)	93(64.1)	
Middle Income Level	15 (10.3)	20 (13.8)	35(24.1)	
High Income Level	5 (3.4)	2 (1.4)	7(4.8)	
Ethnicity				**0.649**
Akan	43 (29.7)	81 (55.9)	124(85.5)	
Ewe	1 (0.7)	6 (4.1)	7(4.8)	
Ga	1 (0.7)	4 (2.8)	5(3.5)	
Hausa/Gonja/Dagbani	3 (2.0)	6 (4.1)	9(6.2)	

Table 4.3 Differences in BMI of Male and Female Diabetic Respondents

Variable	Males	Females	**P-value**
BMI Ranks			0.930
Underweight; BMI < 18.5 kg/m^2	0 (0.0)	1 (0.7)	
Normal, BMI 18.5 to 24.9 kg/m^2	12 (8.3)	38 (26.3)	
Above 25.0 – 29.9 kg/m^2, overweight	15 (10.3)	46 (31.7)	

Above 30.0 kg/m^2, (obese)	7 (4.8)	26 (17.9)

Table 4.4 Prevalence of Cardiovascular Diseases among Diabetics

Cardiovascular diseases	Frequency (%)
Hypertension	96 (66.2)
Stroke	12 (8.3)
Heart failure	5 (3.5)

Table 4.5 Gender and Age of Respondents with and without CVDs

Variable	Diabetics without CVD N=48 (%)	Diabetics with CVD N=97 (%)	P-value
Gender			0.076
Male	7 (4.8)	27 (18.6)	
Female	41 (28.3)	70 (48.3)	
Age			0.000
Below 40 years	12 (8.2)	3 (2.2)	
40 - 60 years	27 (18.6)	50 (34.5)	
Above 60 years	9 (6.2)	44 (30.3)	

4.5 Biochemical Data of Respondents

4.5.1 Fasting Blood Glucose of Participants

Tables 4.8 and 4.9 show biochemical data of participants. The mean FBG levels was high for the whole population, with similar FBG levels for diabetics with and without CVDs. According to Table 4.9, high FBG levels was more prevalent among diabetics with CVDs than those without CVDs but the difference was not statistically significant (p=0.905).

4.5.2 Lipid Profile and Creatinine Levels of Respondents

Dyslipidemia was observed in some of the patients. Hypertriglyceridemia was the most prevalent lipid abnormality (55.9%) followed by hypercholesterolemia (47.6%), elevated LDL (37.2%) and reduced HDL (35.2%) (Table 4.9).

Tables 4.8 shows mean TC levels of diabetic respondents with CVDs was higher than those without CVDs; however, the difference was not statistically significant (p=0.109). The mean TG level of respondents with CVDs was significantly higher than those without CVDs (p=0.005) (Table 4.8). Table 4.9 shows CVD was more prevalent among diabetics with high TG levels.

The mean HDL-C of the respondents with CVDs was significantly lower than those without CVDs (p=0.007). Table 4.9 shows more diabetic respondents with low HDL-C levels had CVDs. The mean LDL-C of the respondents with CVDs was significantly higher than those without CVDs (p=0.005). Table 4.9 reveals more diabetics with high LDL-C levels had CVDs.

Table 4.8 shows 18.6% of the diabetic respondents had high creatinine levels. The mean creatinine level of respondents with CVDs was not significantly higher than those without CVDs (p=0.146) (Table 4.9).

Table 4.6 Anthropometric Data of Diabetic Respondents with and without CVDs

Anthropometric Data	All Respondents No. (%)	Diabetics without CVD N=48 (%)	Diabetics with CVD N=97(%)	P-value
BMI Ranks				0.605
Underweight; BMI < 18.5 kg/m^2	2(1.4)	1 (0.7)	1 (0.7)	
Normal, BMI 18.5 to 24.9 kg/m^2	48(33.1)	19(13.1)	29 (20)	
Above 25.0 – 29.9 kg/m^2, overweight	62(42.7)	19 (13.1)	43 (29.6)	
Above 30.0 kg/m^2, (obese)	33(22.8)	9 (6.2)	24 (16.6)	
Waist Circumference				0.000
Less than 80 cm Normal	32(22.1)	18 (12.4)	14 (9.7)	
Between 80 - 87.9 cm overweight	24(16.5)	1 (0.7)	23 (15.9)	
Above 88 cm (obese)	89(61.4)	29 (20)	60 (41.3)	
Waist to Hip ratio				0.005

Less than 0.90 for male, <0.80 for female, (Normal)	9(6.2)	7 (4.8)	2 (1.4)
Between 0.90 – 0.99 for male, 0.80 – 0.84 for female, (overweight)	41(28.2)	14 (9.7)	27 (18.6)
Above 1.0 for male, 0.85 for female (Obese)	95(65.5)	27 (18.6)	68 (46.9)

Table 4.7 Comparison of Anthropometric and Blood Pressure Data among Diabetic Respondents with and without CVDs

Variable	Mean for All Respondents	Diabetics without CVD (N= 48)	Diabetics with CVD (N= 97)	P-Value
BMI (kg/m^2)	27.39 ± 5.12	27.47 ± 4.90	27.34 ± 5.72	0.885
Waist Circumference (cm)	92.30±15.87	86.31 ±14.30	95.26 ± 15.84	0.001
Hip Circumference (cm)	98.75 ±13.81	98.98 ±15.49	98.63 ±12.98	0.895
Waist to Hip Ratio	0.93± 0.07	0.91 ± 0.08	0.95 ±0.064	0.002
Systolic Pressure (mmHg)	136.21 ±18.17	124.17 ± 12.69	142.16 ± 17.56	0.000
Diastolic Pressure (mmHg)	86.29 ± 9.82	78.96± 9.94	86.29 ± 9.82	0.000

4.6 Oral Medications and Insulin Use

4.6.1 Oral Medications

The type of medications used by the diabetics were grouped as biguanides, sulfonylureas, combined oral medications treatment (which included both sulfonylureas and biguanides), insulin and insulin combined with oral medications (Table 4.10).

From Table 4.10, the most prescribed medication was combined oral diabetic medications (46.9%) and the least prescribed was insulin only (3.4%). Herbal medications was used by

19.3% of diabetics. For the CVD medications, the most prescribed was Calcium-Channel Blockers (43.29%).

Table 4.8 Biochemical Data of Respondents with and without CVD

Variable	Overall mean mmol/L	Diabetics without CVDs (N= 48) mmol/L	Diabetics with CVDs (N= 97)	P-value
Fasting Blood Glucose	9.92 ± 4.15	9.90 ± 4.08	9.98 ± 4.08	**0.905**
Total Cholesterol	5.85 ± 1.45	5.57 ± 1.35	5.98 ± 1.48	**0.109**
Triglycerides	1.95 ± 0.91	1.65 ± 0.84	2.10 ± 0.91	**0.005**
HDL-C	1.20 ± 0.41	1.33 ± .042	1.13 ± 0.38	**0.007**
LDL-C	3.83 ± 1.39	3.02 ± 0.88	4.23± 1.43	**0.005**
Creatinine µmol/l	93.88 ± 30.19	78.96 ±9.94	86.29 ± 9.82	**0.146**

Table 4.9 Biochemical Data of Respondents with and without CVDs

Variable	Diabetic Respondents N=145 (%)	Diabetics without CVD N=48 (%)	Diabetics with CVD N=97 (%)
Fasting Blood Glucose			
Below 3.60 mmol/L	1(0.7)	1 (0.7)	0 (0.0)
Normal 3.60-6.40 mmol/L	32(22.1)	15 (10.4)	17 (11.7)
Above 6.40 mmol/L	112(77.2)	32 (22.1)	80 (55.2)
Total Cholesterol			
Below 3.10 mmol/L	1(0.7)	0 (0.0)	1 (0.7)
Normal between 3.10- 6.50 mmol/L	75(51.7)	28 (19.3)	47 (32.4)
Above 6.50 mmol/L	69(47.6)	20 (13.8)	49 (33.8)
Triglyceride			
Between 0.30-1.70 mmol/L	64(44.1)	31 (21.4)	33 (22.8)
Above 1.70 mmol/L	81(55.9)	17 (11.7)	64 (44.1)
Low density lipoproteins-C			
Below 2.60 mmol/L	27(18.6)	10 (6.9)	17 (11.7)
Normal Between 2.60-4.90 mmol/L	64(44.1)	37(25.5)	27 (18.6)
Above 4.90 mmol/L	54(37.2)	1 (0.7)	53 (36.6)
High density lipoproteins-C			
Below 1.03 mmol/L	51(35.2)	5 (3.5)	46 (31.7)
Normal Between 1.03-1.55 mmol/L	73(50.4)	34 (23.4)	39 (26.9)
Above 1.55 mmol/L	21(14.4)	9 (6.2)	12 (8.3)
Creatinine			
Below 60 µmol/l	8(5.5)	1 (0.7)	7 (4.8)

Normal Between 60-120 µmol/l	110(75.9)	40 (27.6)	70 (48.3)
Above 120 µmol/l	27(18.6)	7 (4.8)	20 (13.8)

Table 4.10 Oral Medications and Insulin Use

Diabetic Medications	Frequency (%)
Combined oral medications (Biguanides and sulphonylureas)	68 (46.9)
Biguanides only	40 (27.6)
Sulfonylureas only	8 (5.5)
Insulin with oral medication	24 (16.6)
Insulin only	5 (3.4)
Herbal Medications Use	
Herbal medications	28 (19.3)
Cardiovascular Medications	**Frequency (%)**
Calcium-Channel Blockers	63 (43.29)
Diuretics 53 (36.08) Angiotensin Converting Enzyme (ACE) inhibitor	29(20.61)

4.7 Family and Medical History

According to Table 4.11 family medical history of hypertension and medical history of diabetes, were the most prevalent with family medical history of hypertension being the more prevalent of the two. There were significant differences for family history of hypertension and family history of diabetes (p=0.001 and p= 0.021) respectively between the diabetics with and without CVDs (Table 4.12).

From Table 4.13, most diabetic respondents (65.5%), had been diagnosed with diabetes for not more than 5 years and 15.2% had been diagnosed with diabetes for more than 10 years. More diabetics with longer duration of diabetes had a significantly higher incidence of CVDs (p= 0.050).

Table 4.11 Family Medical History of Cardiovascular Diseases among All Respondents

Family Medical History	Frequency (%)
Family History of hypertension	68 (46.9)
Family History of Diabetes	67 (46.2)

Family History of Stroke	27 (18.6)
Family History of Heart Failure	6 (4.1)

Table 4.12 Family Medical History among Respondents with and without CVDs

Family Medical History	Diabetics without CVD N=48 (%)	Diabetics with CVD N=97(%)	P-value
Family History of Hypertension	16 (23.5)	52 (76.5)	**0.001**
Family History of Diabetes	13 (19.4)	54 (80.6)	**0.021**
Family History of Stroke	6 (22.22)	21 (77.8)	**0.078**
Family History of Heart Failure	0 (0%)	6 (100)	**0.183**

Table 4.13 Duration of Diseases among Respondents with and without CVDs

Variable	Diabetic Respondents No. (%)	Diabetics without CVD N=48 (%)	Diabetics with CVD N=97 (%)	P-value
Duration of Diabetes				**0.050**
Not more than 5 years	95(65.5)	38 (26.3)	57 (39.3)	
Between 6-10 years	32(22.0)	6 (4.1)	26 (17.9)	
Above 10 years	18(15.2)	4 (2.8)	14 (9.6)	

4.8 Dietary Habits of Respondents

Tables 4.14 and 4.15 show the dietary habits of the diabetic participants. Most diabetic respondents (62.1%) ate thrice daily. The diabetics with CVDs who ate thrice daily were more than those without CVDs. The number of times diabetic respondents ate their main meals daily did not show any significant differences (p=0.071) (Table 4.15).

The results on vegetable intake (Tables 4.14), shows most diabetic respondents (62.1%) ate vegetables thrice in a week, whilst 8.3% ate vegetables occasionally. The vegetable intake among the diabetics with CVDs was higher than those without CVDs. However, the difference was not significant (p=0.09) (Table 4.15).

Data on fruit intake (Tables 4.14 and 4.15), reveal majority of the respondents 80 (56.6%) ate fruits less than twice a week. On fruit intake, diabetics with CVDs ate fruit more than those without CVDs. Nonetheless, the difference in fruit intake between the diabetics with and without CVDs was not significant (p= 0.68).

From Table 4.14, most diabetic respondents (56.6%) had low salt intake, whilst 9.0% had high salt intake. Table 4.15 shows all the diabetic respondents with high salt intake had CVDs, whilst none of the diabetics without CVDs had high salt intake. On salt intake, diabetics without CVDs had significantly lower salt intake than those with CVDs (p= 0.00).

Table 4.14 reveals most diabetic respondents (56.6%) consumed canned foods occasionally. The diabetics with CVDs who consumed canned foods were more than those without CVDs but the difference was not statistically significant (p=0.225) (Table 4.15). Table 4.14 shows the type of oil mostly consumed by diabetics was saturated fat (82.1%). From Table 4.15, diabetics who took saturated fat had more CVDs than those without CVDs, but this did not show any significant differences (p=0.460).

Table 4.14 Dietary Habits of All Diabetic Respondents

Variable	Frequency (N=145) (%)
Main Meal	
Thrice	90 (62.1)
less than thrice	53 (36.6)
More than thrice	2 (1.4)
Vegetables Intake	
Thrice in a week	78 (53.8)
Less than twice in a week	55 (37.9)
Occasionally	12 (8.3)
Fruits Intake	
Thrice in a week	33 (22.8)
Less than twice in a week	82 (56.6)
Occasionally	30 (20.7)
Salt Intake	

Low	82 (56.6)
Moderate	50 (34.5)
High	13 (9.0)
Canned Foods Intake	
Daily	15 (10.3)
Weekly	22 (15.2)
Occasionally	108 (74.5)
Type of oil Used	
Vegetable oil (unsaturated fat)	26 (17.9)
Non-vegetable oil (unsaturated fat)	119 (82.1)

4.9 Participants' Physical Activity Levels and Lifestyle

Tables 4.16 and 4.17 show the lifestyle and physical activity levels of diabetic respondents. The greater majority of the diabetics participants (94.5%) live a sedentary lifestyle (by virtue of; time spent sitting/reclining per day, time spent walking and lack of moderate physical activity at work). On physical activity 61.4% of diabetics did not exercise. Diabetics without CVDs had significantly higher physical activity (p=0.00) (Table 4.17).

Smoking status, showed most diabetics (91%) had never smoked whilst (9%) were ex-smokers (Table 4.16). Ex-smokers were more prevalent among diabetics with CVDs than those without CVDs (Table 4.17). From Table 4.18, significantly higher proportion of males were exsmokers (p=0.00). Moreover, significantly higher prevalence of smoking was observed among diabetics with CVDs than those without CVDs (p= 0.041) (Table 4.17). For alcohol consumption, most diabetic respondents (54.4%) had never drunk alcohol, whilst 11.7% were current drinkers. From Table 4.18, more males than females were current drinkers with significant differences (p=0.00). Alcohol consumption was more prevalent among diabetics with CVDs than those without CVDs, though there was no significant difference (p=0.748)

(Table 4.17).

Table 4.15 Dietary Habits of Diabetic Respondents with and without CVDs

Dietary Habits of Respondent	Diabetics without CVDs N=48 No. (%)	Diabetics with CVDs N=97 No. (%)	P-value
Main Meal			**0.071**
Thrice	26 (17.9)	64 (44.2)	
less than thrice	20 (13.8)	33 (22.7)	
More than thrice	2 (1.4)	0 (0)	
			0.091
Vegetable Intake			
Thrice in a week	32 (22.1)	46(31.7)	
Twice and below	13 (8.9)	42 (28.9)	
Occasionally	3 (2.2)	9(6.2)	
Fruit Intake			**0.6 98**
Thrice in a week	11 (7.6)	19 (13.1)	
Twice and below	28 (19.3)	54 (37.2)	
Occasionally	9 (6.2)	24 (16.6)	
Salt Intake			**0.000**
Low	40 (27.6)	42 (29.0)	
Moderate	8(5.5)	42(29.0)	
High	0 (0.0)	13 (8.9)	
Canned Foods Intake			**0.225**
Daily	3(2.1)	12 (8.3)	
Weekly	5(3.4)	17 (11.7)	
Occasionally	40 (27.6)	68 (46.9)	
Type of Oil Used			**0.460**
Vegetable oil / unsaturated fat	7 (4.8)	19 (13.1)	
Non vegetable oil / saturated	41 (28.3)	78 (53.8)	

Table 4.16 Lifestyle and Physical Activity Levels of All Diabetic Participants'

Lifestyle of Respondents	Frequency (%) (N=145)
Time Sitting	
More than 30 minutes	137 (94.5)
30 mins	8 (5.5)
Exercise Type	
Vigorous intensity	4 (2.8)
Moderate intensity	52 (35.9)
Never	89 (61.4)
Walk for 10 mins	
Yes	133 (91.7)
No	12 (8.3)

Smoking Status	
Never smoked Current	132 (91.0)
Smoker	0 (0.0)
Ex-smoker	13 (9.0)
Drinking Status	
Never drank alcohol	79 (54.5)
Current drinker	17 (11.7)
Ex-drinker	49 (33.8)

Table 4.17 Diabetic Participants' Lifestyle and Physical Activity of Respondents with and without CVDs

Lifestyle of Respondents	Diabetics without CVD No. (%)	Diabetics with CVD No. (%)	P-value
Time Spent Sitting			**0.001**
Less than 30mins	7 (4.8)	1 (0.7)	
More than 30 mins	41 (28.3)	96 (66.2)	
Exercise Type			**0.000**
Vigorous intensity	4 (2.8)	0 (0.0)	
Moderate intensity	36 (24.8)	16 (11.1)	
Never	8 (5.5)	81 (55.8)	
Smoking Status			**0.041**
Never smoked	47 (32.4)	85 (58.6)	
Ex-smoker	1 (0.7)	12 (8.3)	
Drinking Status			**0.748**
Never Drank Alcohol	25 (17.3)	54 (37.2)	
Current drinker	7 (4.8)	10 (6.9)	
Ex-drinker	16 (11.1)	33 (22.7)	

Table 4.18 Differences in Smoking Status of Male and Female Diabetic Respondents

Variable	Males	Females	**P-value**
Smoking Status			0.000
Never smoked	25 (17.2)	107 (73.8)	
Ex-smoker	9 (6.2)	4 (2.8)	
Drinking Status			0.000
Never drinks	15 (10.3)	64 (44.2)	
Current drinker	12 (8.3)	5 (3.4)	
Ex-drinker	7 (4.8)	42 (29.0)	

4.10 Association between CVD and Some Selected Risk Factors among Diabetic Patients

Association between CVD and selected risk factors such as gender, age, BMI, waist hip ratio, waist circumference, systolic blood pressure, diastolic blood pressure, exercise type, smoking status, alcohol intake, family medical history of hypertension, family medical history of diabetes, family medical history of stroke and family medical history of heart failure, FBS, total cholesterol, triglyceride, HDL-C, LDL-C and creatinine levels with CVD was conducted using Pearson chi-square for categorical variables, t-test for continuous variables and crosstabulated comparison of risk among respondents with CVD and those without CVD.

The analysis revealed risk factors such as gender, family history of stroke or heart failure, BMI, total cholesterol, fasting blood glucose, creatinine levels, fruit and vegetables intake and alcohol consumption had insignificant association with cardiovascular disease incidence among diabetics. Therefore these variables were removed from the binary logistic regression analysis.

The significant predictors of CVD among the DM patients were age, waist circumference, WHR, exercise, family medical history of hypertension, family medical history of diabetes, salt intake, smoking status, triglyceride levels, HDL-C and LDL-C. These were used for further analysis by binary logistic regression. The results of the bivariate analysis (Table 4.20), family history of hypertension had an odds ratio (OR) (OR=6.789, 95% CI 1.391- 33.14), exercise (OR=0.104, 95% CI 0.028 – 0.394), salt intake (OR= 0.113; 95% CI 0.022 – 0.589) and HDLC levels (OR=0.181, 95% CI 0.036-0.0912) from the regression model.

Even though individually, some of the independent variables were significantly associated with CVDs, when they were put together, some of the variables had no significant association with

CVDs.

The logistic regression co-efficient (b) from the analysis (Table 4.20) showed that individuals who exercise (either vigorous/ moderate intensity exercise) had decreased incidence of CVDs, compared to those who do not exercise, with logistic regression co-efficient of (b= -2.261) at $p<0.05$. Individuals with low salt intake had decreased incidence of CVDs, compared to those who had high/moderate intake with logistic regression co-efficient of (b= -2.183) at $p<0.05$. HDL-C levels show that individuals with normal levels had decreased incidence of CVDs, shown by logistic regression co-efficient of (b= -1.708) at $p<0.05$. Family medical history showed that individuals with family history of hypertension had increased risk of CVDs incidence compared to individuals without family history of hypertension with logistic regression co-efficient of (b= 1.915) at $p<0.05$.

Table 4.19 Selected Risk Factors associated with CVDs among Diabetic Patients

Variables	P-value
Age (yrs.)	0.000
Salt-Intake	0.000
Exercise Type	0.000
Family History of Diabetes	0.021
Family History of Hypertension	0.001
Smoking Status	0.041
Waist-Circumference (cm)	0.0002
Waist Hip Ratio	0.005
Triglycerides (mmol/L)	0.005
HDL-C (mmol/L)	0.007
LDL-C (mmol/L)	0.005

Table 4.20 Significant Risk Factors Independently Associated with CVD Incidence among Diabetic Respondents with and without CVDs in Logistic Model

Variables	b	Odds Ratio (OR)	95% Confidence Interval	P-Value
Age	-.300	0.741	0.122 - 4.45	0.744
Salt-Intake	**-2.183**	**0.113**	**0.022 - 0.589**	**0.010**
Exercise Type	**-2.261**	**0.104**	**0.028 - 0.394**	**0.001**

Family History of Diabetes	1.420	4.137	0.925 - 18.496	0.063
Family History of Hypertension	**1.915**	**6.789**	**1.391- 33.140**	**0.018**
Smoking Status	-2.468	0.085	0.002-3.596	0.197
Waist-Circumference	-.886	0.412	0.079 - 2.143	0.292
Waist Hip Ratio	-1.342	0.261	0.009 - 7.252	0.429
Triglycerides	-1.225	0.294	0.075 -1.154	0.079
HDL-C	**-1.708**	**0.181**	**0.036-0.0912**	**0.038**
LDL-C	-19.971	0.000	0.00	0.997

CHAPTER FIVE

DISCUSSION

5.0 Introduction

The results revealed that cardiovascular diseases; hypertension, stroke and heart failure were observed among diabetes patients. However, hypertension was the most prevalent. In the study, risk factors including age, central obesity, dyslipidemia, lack of exercise, family history of hypertension or diabetes, salt intake and smoking status had significant association with risk of cardiovascular diseases among diabetes patients. Other risk factors such as gender, general obesity, FBG level, creatinine level, fruit and vegetable intake, family history of stroke or heart failure and alcohol consumption showed no significant association with cardiovascular diseases among diabetes patients.

5.1 Baseline Characteristics of Participants

In this study, data on sociodemographic characteristics (Tables 4.1) revealed, majority (76.6%) of the respondents were females. Correspondingly, similar results of 70.3% females with diabetes was observed by Acheampong (2010) in Ghana. Further similar observations of high proportion of females with diabetes were also made by Wild *et al.* (2004), Titty (2009), Adibe *et al.* (2009) and Cunningham-Myrie *et al.* (2013). This result does not mean that majority of diabetic patients are females but it could be that the females are more concerned of their diabetic

status and may seek medical treatment regularly. Another reason for this observation could be that at the time of the study more females were due for their routine hospital attendance than the males.

The high proportion of female diabetics in this study could be linked to the high incidence of obesity among women observed in the study. Also, women have smaller muscle mass available for the uptake of the glucose than men (Faerch *et al.*, 2010).

High levels of estrogen and progesterone found in females, both of which can reduce insulin sensitivity among females and can also genetically predispose them to diabetes (Franconi *et al.*, 2012). Furthermore, more elderly women than men in most populations could be a contributing factor for this observation (Wild *et al.*, 2004). The significantly high prevalence of diabetes in women in the study is in contrast with data from India by Chow *et al.* (2006) and in China by Yang *et al.* (2010) in which diabetes was more predominant in men than women.

Data on age (Tables 4.1and 4.2) showed, majority of the respondents with CVDs were above 40 years and this is similar to the finding of Fourlanos *et al.* (2008) and Okereke *et al.* (2008). The results of the study showed a directly proportional association between increasing age and prevalence of diabetes and CVDs among the study subjects, with participants between 51-60 years being the most affected. The increasing prevalence of DM with age, particularly after 40 years observed in this study is in agreement with results from India by Kokiwar *et al.* (2012) and Raghupathy *et al.* (2007). This supports ageing to be a risk factor for diabetes in Africa, which is in line with predictions by Hall *et al.* (2011) and Guariguata *et al.* (2011) that, prevalence of diabetes will shift from the elderly (>65 years) to younger age-groups. In subSaharan Africa, prevalence of chronic diseases such as diabetes and CVDs increase with age (Baldé *et al.*, 2007; Motala *et al.*, 2008). Age is the most powerful unmodifiable risk factor

for atherosclerosis (Jousilahti *et al.*, 1999). As age increases above 45 years the risk of cardiovascular event increases. This is because accumulated risk factors in an individual increase with age (Jousilahti *et al.*, 1999).

The high incidence of diabetes and CVDs among the aged is consistent with lower physical activity, obesity and adoption of unhealthy lifestyles among diabetics, as reported by Kokiwar *et al.* (2012). This shift in age range has deleterious consequences on national economies, hence efforts geared towards addressing this problem will yield economic and public health benefits.

The educational status showed majority of diabetic patients were primary school drop-outs (Tables 4.1). The findings on educational status concur with studies made by Abebe *et al.* (2015), in Turkey, Berhe *et al.* (2014) in Pakistan in which majority of DM patients were found to have only primary school educational level. The presence of large proportion of diabetics who have lower level of education may also reflect a large number of poorly educated people among the study population, hence the level of education should be taken into consideration during nutritional counselling. Although most participants were employed, majority were in the low income class which is similar to results by Gezawa *et al.* (2015), in North-Eastern Nigeria and Cunningham-Myrie *et al.* (2013) in Australia. The low income levels among respondents could be attributed to the low educational levels among respondents, as high educational level is associated with better income status.

5.2 Anthropometric Data of Respondents

Anthropometry data (Table 4.6) revealed, majority of the participants were either overweight (42.7%) and obese (22.8%). The anthropometric data showed no association of cardiovascular diseases with BMI. Rahmanian *et al.* (2014) reported similar prevalence of overweight and obesity among diabetic patients in Iran with a prevalence of overweight and obesity as 48%

and 28% respectively. Al-Sharafi and Gunaid (2014) also showed similar findings among diabetic patients in Yemen, as 58.5% were overweight and 28.8% were obese. In agreement with this study, a study by Pandeya *et al.* (2012) showed that 39.0% and 11.0% of the diabetics to be overweight and obese, respectively. The high proportion of respondents being overweight and obese could be due to non-modifiable factors such as ageing and family history of obesity and also influenced by modifiable factors such as poor diet, sedentary lifestyle of respondents, lack of emphasis on the management of obesity during dietary counselling among diabetics and the use of medications, such as sulphonylureas and insulin (Connor *et al*., 2003). BMI or obesity increases with age, as reported by Lobstein *et al.* (2004) so the high overall mean BMI of the study participants could be because all respondents were adults above 18 years.

However, the findings on BMI was in marked contrast with the overweight and obesity prevalence reported by Thomas *et al.* (2006), Joseph *et al.* (2004), Shera *et al.* (2004), Esmaillzadeh *et al.* (2007) and Daousi *et al.* (2006). The variations in prevalence of overweight and obesity among diabetics in various studies could be due to factors like environmental differences, lifestyle, employment status and genetic factors of the population (Connor *et al*., 2003).

Among the respondents overweight and obesity was more prevalent among females than males (Table 4.3). This concurs with a study by Basukala *et al.* (2014) which showed that obesity was found more prevalent among women than men. One reason for this difference could be attributed to sex hormones. In males, testosterone is responsible for the high muscle mass-tofat mass ratio (Powers and Howley, 2007) whereas oestrogen is responsible for more fat distribution in females (Powers and Howley, 2007). Furthermore, the high prevalence of

obesity among African females could reflect their belief that overweight and obesity indicate health status and the wealth of their spouses (Puoane *et al.*, 2005).

Similar to our result, most studies showed higher frequency of overweight and obesity in diabetic women, compared to men. Similarly, the high rate of overweight and obesity found among Ghanaian females in our study was consistent with the findings of Kruger *et al*. (2005) and Croft *et al*. (1995) which stated that anthropometric measures were higher in AfricanAmerican females, compared to Caucasian females.

BMI does not factor the proportion of weight related to muscle or fat distribution in the body. Individuals with similar BMI can vary considerably in their abdominal-fat mass, with premenopausal women characteristically having more abdominal-fat mass than men (Lemieux *et al.*, 1994). Furthermore, BMI has considerable limitations in predicting intra-abdominal fat accumulation (Chen *et al.*, 2000). For this reason data on WHR and waist circumference were also determined, to ascertain CVD risk factors and its correlations with BMI.

The prevalence of abdominal obesity in this study was 61.4% and 65.5% for waist circumference and waist to hip ratio respectively (Table 4.6). Data on waist circumference and waist to hip ratio showed that majority of respondents had abdominal obesity. This means, central obesity as per waist-hip ratio and waist circumference was more prevalent than general obesity in diabetics. The anthropometric data showed significant association of cardiovascular diseases with central obesity. This findings is in agreement with findings of Raimi *et al.* (2015), Ahaneku *et al.* (2011), Ulasi *et al.* (2010). The finding that central obesity was more prevalent than general obesity in diabetics was consistent with study by RezaDerakhshan and Asghar (2010) and Al-Nozha e*t al.* (2007) in which 58.2% and 66.5% type 2 diabetics respectively had abdominal obesity.

The prevalence of abdominal obesity (Table 4.6) was however, higher than results from Nigeria by Siminialayi *et al.* (2008) as 31.7% and Sodjinou *et al.* (2008) as 32.0%. The prevalence of abdominal obesity was significantly higher in female than in male respondents, which is in agreement with several studies in other African countries, by Maher *et al.* (2011), Shayo and Mugushi *et al.* (2011) and Wahab *et al.* (2011). This finding may be attributed to low levels of physical activity among females and the notion that being obese is considered as a sign of wellbeing in Africa (Ojofeitimi *et al.*, 2007).

Abdominal obesity was found to be linked with increased risk of CVD among diabetics in the study. Abdominal obesity is connected to insulin resistance and abnormal blood lipid levels (Ness-Abramof and Apovian, 2008). This results in accumulation of pro-inflammatory cytokines and C-reactive protein and reduced adiponectin levels. The combined effects of these metabolic abnormalities thus lead to a higher cardiometabolic risk and subsequently cardiovascular disease (Ness-Abramof and Apovian, 2008; Dinarello, 2000). Ho *et al.* (2001), in a comparative study of several anthropometric measures, proved waist circumference was effective in identifying CVD risk factors.

5.3 Dyslipidemia

Studies have shown categorically that lipid abnormalities in patients with diabetes is associated with increased risk of cardiovascular disease (Goldberg, 2001; Krauss, 2004). Findings from this study in Table 4.9, show prevalence of hypercholesterolemia, hypertriglyceridemia, low HDL-C, and high LDL-C levels which are well known risk factors for cardiovascular diseases among diabetic patients. Table 4.9 shows that 47.6% and 55.9% of the diabetic patients had high total cholesterol and high triglyceride levels, putting them in the high risk for cardiovascular disease. The results show that dyslipidemia is more severe and prevalent among

diabetic patients with CVD than diabetic patients without CVD. Diabetics with CVDs had significantly higher triglyceride levels, lower HDL-C and higher LDL-C levels (Table 4.8). The pattern of dyslipidemia observed in the present study was similar to reports by AbdulRamman and Olufunsho, (1995) in Saudi Arabia, where dyslipidemia was observed in the range of 25-60%, among diabetic patients.

The results on prevalence of dyslipidemia in the present study was also consistent with results of Sawant *et al.* (2008) in India, which revealed the prevalence of hypercholesterolemia, hypertriglyceridemia, abnormally high levels of LDL-C and low HDL-C levels among diabetics. The elevated levels of LDL in this study was also observed by Saaddine *et al.* (2002) in USA and in Jordan by Abdel-Aal *et al.* (2008) among diabetics. A study in Nigeria showed similar findings, where hypercholesterolemia and hypertriglyceridemia were 43.5% and 34.8% respectively, among DM patients. The prevalence of hypercholesterolemia and hypertriglyceridemia in this study was consistent with results of Jayarama *et al.* (2012).

The variations in lipid abnormalities can be attributed to different lifestyles among these subjects, including diet and exercise, differences in insulin sensitivity, and other social habits. Diabetic patients can have many lipid abnormalities, including elevated levels of low density lipoprotein cholesterol (LDL-C) and triglycerides, and low levels of high- density lipoprotein cholesterol (HDL-C) (Haffner *et al.*, 1998). In diabetes, it is the impaired glucose metabolism that leads to hyperglycemia and subsequently dyslipidemia. Vascular complications and lipid abnormalities in diabetics can be prevented by controlling elevated blood glucose levels (Marcus, 2001; Lehto *et al.*, 1997).

From Table 4.9, the participants with CVDs had higher levels of LDL-C and TG compared with those without CVDs. This is consistent with the studies of Akintunde *et al.* (2015) and

Ojji *et al.* (2009) in Nigeria, where high levels of LDL-C and TG were reported in patients with hypertension. The increasing prevalence of dyslipidemia among the respondents with CVD and those without CVD in this study could be attributed to urbanization, adoption of western diet and differences in lifestyle, characterized by physical inactivity among diabetics, as reported by Kokiwar *et al.* (2012). Improving the lipid profile among diabetics is important, as it is reported that dyslipidemia is associated with CVD (National Institutes of Health, 2001).

5.4 Creatinine

Plasma creatinine and urea have been reported as potent markers of glomerular filtration rate (GFR). However, plasma creatinine gives a more accurate measure of kidney function, compared to plasma urea level and this is attributed to the fact that creatinine fulfills the requirements for a perfect filtration marker (Perrone *et al.*, 1992). Creatinine levels are usually elevated when the kidneys have lost about 50% of their function (Perrone *et al.*, 1992). The results on creatinine levels (Table 4.9) showed no significant difference among participants with cardiovascular disease and those without cardiovascular disease. Out of the diabetic respondents studied, 18.6% had high creatinine levels (Table 4.9). This observation is in accordance with the reports by Adler *et al.* (2003), Judykay (2007) and Wagle (2010) in which high creatinine levels observed in diabetic patients indicated impaired function of the nephrons. Research by Anjaneyulu and Chopra (2004) found elevated serum creatinine levels in diabetic rats indicated progressive renal damage. Similar findings to the current study were reported by Luepker *et al.* (2003), Antman *et al.* (1996) and Wilmer *et al.* (2000) in which significantly high plasma creatinine levels were observed in diabetic patients, compared with nondiabetics.

5.5 Fasting Blood Glucose Levels

Poor glycemic control was observed in most diabetic patients, even though all of them were on antidiabetic medications. The results on FBG (Table 4.9), shows no significant differences

among participants with cardiovascular diseases and those without cardiovascular diseases. Some of the reasons of hyperglycemia among diabetes patients are a carbohydrate-rich local diet, physical inactivity, lack of knowledge about diabetes and inadequate knowledge on treatment protocol, as reported by Eid *et al.* (2004). Poor glycemic control status has also been reported in other studies in developing and developed countries among diabetes patients (Ismail *et al.*, 2000). A study by Ismail *et al.* (2000) in Malaysia and Rotimi *et al.* (2004) in Nigeria also documented poor glycemic control among diabetic patients.

However, the results on FBG levels contrasted with findings by Jifeng in (2006) in USA, Reisig *et al.* (2007) in Germany and Arai *et al.* (2009) in Japan, who reported good glycemic control among diabetes patients. The good glycemic control status in these countries might be because of the higher literacy levels, resulting in better knowledge about DM (Reisig *et al.*, 2007). Other factors associated with good glycemic control can be dosage of medication or insulin, compliance with management regimens, self-monitoring of blood glucose and socio-economic differences in groups, leading to greater improvements in FBG levels (Benoit *et al.*, 2005). Some of the factors that influence diabetes control and management could be socio-economic status which are also associated with access to health care, healthcare utilization, use of medication and access to good nutrition (Corpus *et al.*, 2004).

5.6 Prevalence of Cardiovascular Disease among DM Patients

Epidemiological data on cardiovascular disease in diabetics vary throughout the world. The prevalence rate of hypertension, stroke and heart failure in diabetic patients were 66.2%, 8.28% and 3.45% respectively (Table 4.4). The findings in this study highlight the burden of hypertension across the populations in Ghana and also corroborate the documented pattern of rise in the hypertension prevalence in diabetic patients, as 63% found by Okoro and Oyejola in

(2004) among diabetics in Nigeria. The findings in this research is also consistent with findings of other researchers who demonstrated a high prevalence of hypertension among diabetes patients (Unadike *et al.*, 2011; Pancha et *al.*, 2012; Basavegowda *et al.*, 2014) but clearly higher than those previously described in other sub-Saharan African countries by Dembele *et al.* (2000), Asekun-Olarinmoye *et al.* (2013) and Ogah *et al.* (2014). The level was lower than that of United Kingdom with hypertension prevalence of 73% and USA with a hypertension prevalence of 77%, where diet, physical inactivity and obesity have collectively caused this increased prevalence of hypertension (Kearney *et al.*, 2005).

This study's 8.28% overall prevalence of stroke (Table 4.4) is consistent with reported stroke prevalence of 8% reported in SSA and 9.3% in Nigeria by Oni *et al.* (2008). This is also consistent with findings of other researchers (Tseng *et al.*, 2004; Agyeman *et al.*, 2006), but greatly exceed that reported in Nigeria, where stroke constituted 0.36% of the total hospital admissions from 1994 to 1998 (Njoku and Aduleju, 2004).

The stroke prevalence among diabetes patients can be attributed to poor control of blood pressure, a powerful predictor of stroke and responsible for nearly 70% of all stroke cases (Lavados *et al.*, 2005; WHO, 1997; Bronner *et al.*, 1995). The prevalence of stroke among diabetes patients can be attributed to ignorance of common risk factors, non-compliance with diabetes medication and nonattendance to clinic, as reported by some of the respondents and health professionals. This correlates with reports of other studies in Africa by Mohammed *et al.* (2000), Agyemang et *al.* (2006) and Van der Sande *et al.* (2000).

The present study showed a heart failure prevalence of 3.45% among diabetes patients (Table 4.4). The prevalence of heart failure (HF) can be attributed to the high prevalence of hypertension observed among the diabetic respondents. The causes of heart failure in SSA are

mostly hypertension, valvular heart diseases and various cardiomyopathies among adults (Sliwa *et al.*, 2005; Commerford and Mayosi, 2006). In diabetics, risk factors that partly account for the incidence of HF include diabetic-specific cardiomyopathy, accelerated coronary atherosclerosis and other diabetes-related risk factors (Adlerberth *et al.*, 1998). Nevertheless, factors such as dyslipidemia, hypertension, anemia from malnutrition, hypercoagulability, obesity and inflammation in people with diabetes, increase the risk of experiencing cardiovascular complications (Stamler *et al.*, 1993; Steyn *et al.*, 2005). Pathological changes in the myocardium of diabetics can lead to development of heart failure linked with sustained hyperglycemia, impaired insulin resistance and accumulation of collagen and other glycation end-products (Bell, 1995).

In patients with diabetes the prevalence of heart failure is between 9–22%, which is much higher, compared to the general population Adriaan *et al.* (2011). The result of the study was contrary to 19% diabetics with heart failure patients by Amoah and Kallen (2000). It is lower than the prevalence of heart failure among diabetics, reported by Bauters *et al.* (2003), Garty *et al.* (2007) in Israel and Ola *et al.* (2006) in Nigeria. This study shows low prevalence of HF among patients with diabetes in Ghana, compared to other regions in Africa. One of the reasons for the reported low prevalence of HF may be due to a lack of diagnostic facilities, as these are available only in a few urban health centers (Kengne *et al.*, 2005).

5.7 Dietary Habits of Respondents

Dietary patterns signify the combination of foods habitually consumed, which together produce synergistic health effects (Mozaffarian *et al.*, 2011; Perrin *et al.*, 2002). For the many risk factors associated with high blood pressure (HBP), the dietary exposure most investigated has been daily salt consumption.

The data on salt intake (Table 4.14) revealed that salt intake among respondents was low. The low intake of sodium among most respondents is likely due to the high prevalence of hypertension among the diabetes patients. Dietary sodium restriction (to <3 grams/day) is an important component of management of any patient with hypertension (Uzu *et al.*, 2006; Sacks *et al.*, 2001; Hoffmann and Cubeddu, 2007).

Excess sodium intake contributes to hypertension directly, by increasing intravascular volume, and indirectly, by blunting the effectiveness of antihypertensive drugs (Ekinci *et al.*, 2011; Pimenta *et al.*, 2009). Subsequently, clinical guidelines recommend a reduced intake of salt as a measure to maintain a blood pressure at or below target levels in patients with diabetes (Elliott *et al.*, 1996; Vedovato *et al.*, 2004; Provenzano *et al.*, 2014).

It has been documented that a reduced sodium intake can prevent hypertension (Huang *et al.*, 1998*)* and lower BP in patients on antihypertensive medication (Weir *et al.*, 1997; Appel *et al.*, 2001) and can facilitate hypertension control. The data on salt intake (Table 4.15) shows significant differences in salt intake among respondents with cardiovascular disease and those without cardiovascular disease. This indicates that sodium intake is associated with the incidence of cardiovascular disease among diabetes patients. Meneton *et al*. (2005) stated that strong relationship between high salt intake and high blood pressure in human and animal models.

The finding of low salt intake observed among diabetics is consistent with reviews that reported reduced sodium intake decreased blood pressure in adults (Graudal *et al.*, 2012; Dickinson *et al.*, 2006; Dietary Guidelines Advisory Committee, 2010). However, the low sodium intake among diabetics in this study was contrary to high salt intake observed by Provenzano *et al.*

(2014) in Pennsylvania. This difference is likely due to concerns by other researchers that a reduction in sodium intake might lead to adverse health effects such as increased total cholesterol, low density lipoprotein cholesterol, triglycerides and catecholamine levels, as well as adverse changes in renal function or adverse effects on cardiovascular risk (Alderman and Cohen, 2012).

5.8 Fruit and Vegetable Intake

Results on fruit and vegetable intake (Table 4.14) reveal inadequate fruit and vegetables intake, compared to the 9 servings/day of fruit and vegetables, provided in a DASH diet. As the majority of respondents consume vegetables thrice or below in a week. The fruit and vegetable intake among respondents with CVD and without CVD showed no significant differences.

A number of compounds may contribute to the cardioprotective effects of fruit and vegetables, including vitamin C, folate, potassium, fiber and phytochemicals (Bazzano *et al.,* 2003). The insufficient intake of fruit and vegetables among respondents is linked with several socioeconomic, demographic, nutritional knowledge, personal and environmental factors (Rasmussen *et al.*, 2006; Bonomo *et al.*, 2003). Other factors responsible for the low consumption of fruit and vegetables, are related to the availability, accessibility, cost and quality of the food (Cummins *et al.*, 2009). High fruit and vegetable intakes are related to a healthy dietary pattern (Hu *et al.,* 1999; Hu *et al.,* 2000).

The results of the study are similar to the results of Hall *et al.* (2009) in which 78.0% of respondents from mainly low-and middle-income countries consumed less than the recommended five daily servings of fruits and vegetables, with Ghana, Bangladesh, Ukraine and Malawi, recording outstandingly low fruits and vegetables consumption (Hall *et al.*, 2009).

The low intake of fruits and vegetables in the current study is similar to a survey in South Africa by Hall *et al.* (2011), Appleton *et al.* (2009) in Northern Ireland and Health Survey in England in which low fruit and vegetable consumption was observed among diabetics. Studies have confirmed that frequent fruit and vegetable consumption was associated with a 6–22% lower risk for coronary heart disease mortality (Van't Veer *et al.*, 2000).

A meta-analysis that combined the results of 11 prospective cohort studies found that people in the 90th percentile of fruit and vegetable intake (about 5 servings/day or more) had a 15% lower risk of cardiovascular diseases than those in the 10th percentile of intake (Law and Morris, 1998). Studies have shown that consuming more than five daily servings of fruit and vegetables is associated with 17% reduction in risk of cardiovascular disease, compared with consumption of less than three servings daily (He *et al.,* 2007). Fruit and vegetable consumption varies considerably among and within countries, in large part reflecting, the prevailing economic, cultural and agricultural environments, but consumption in many parts of the world remains low (Hall *et al.,* 2009).

5.9 Lifestyle of Respondents

The results on lifestyle (Table 4.16) from the study revealed, none of the diabetes patients was currently smoking, which can be attributed to low prevalence of smoking in Ghana, as reported by Pampel (2008). Another likely reason for this can be due to the ban on public smoking in Ghana and also health workers advising patients to desist from smoking. Cultural factors may also have had a strong influence on the pattern of smoking in Ghana. In reality, the low smoking prevalence in Ghana reflects a mix of cultural and political influences (Addo *et al.,* 2008). There is also likelihood that patients will not admit smoking even if they smoked and this could underestimate the effect of smoking.

The low number of female ex-smokers, compared to their male counterparts in our study is a typical finding in African countries (Pampel, 2008; Rudatsikira *et al.*, 2007). This has been attributed to limited opportunities to smoke, coupled with low levels of economic independence among women and sociocultural contexts within which smoking among women is often considered to be immoral (Rudatsikira *et al.*, 2007). Smoking is generally five times more prevalent among males than females; in Nigeria smoking status was found to be a significant risk factor CVDs in males only (Ekpenyong *et al.*, 2012).

However, findings of the study is contrary to the prevalence of cigarette smoking among diabetic patients in Pakistan reported by Khalid *et al.* (2014) and World Bank (2009) as 27% and 34.47% respectively. Contrarily, cigarette smoking in this study was low, compared with 17% in Los Angeles by Johnson (2001) and 12.4% European by Scemama *et al.* (2006) among diabetics. This difference in smoking prevalence is likely due to the lifestyle of the society, cultural differences and health education given by the health professionals. However, being an ex-smoker had significant relationship with risk of cardiovascular disease among diabetes patients.

Smoking accelerates the ageing process and hastens death according to Wellman and Kamp (2008). Smoking has a negative impact on health status, in addition to risks of lung cancer. Smoking is a risk factor for cardiovascular morbidity, mortality and the development of myocardial infarction (Peters *et al.*, 2008). Smoking is linked with deterioration in metabolic control in diabetic patients (Bott *et al.*, 1994) which is associated with an increased risk for development of macrovascular complications (Morrish *et al.*, 1991). Data on lifestyle of smoking (Table 4.17) with p-value of 0.041 showed, that smoking was significantly associated with the CVD incidence among diabetes patients. This is because nicotine intake as result of

smoking, decreases insulin sensitivity, directly or indirectly increases circulating free fatty acid levels, and also affects the autonomic nervous system and this is an additional negative factor for the insulin-mediated glucose uptake which are implicated in cardiovascular disease progression (Bergman and Ader, 2000; Kirschbaum *et al.,* 1992; Lucini *et al.,* 1996).

The prevalence of cigarette smoking among diabetic patients in this survey could not be compared with values from most countries of sub-Saharan African regions because most African countries have not conducted studies in this regard to establish the base line prevalence rate.

5.10 Physical Activity Levels

The results of the study from Table 4.16, show the physical activity level of the participants was predominantly low as 61.4% did not exercise, whilst 35.9% and 2.8% of the participants engaged in moderate and vigorous intensity exercise respectively. The results above concur to the findings of Oguntibeju *et al.* (2012), in a study in Nigeria in which 62% of the patients showed low physical activity levels, while 34% and 4% of them had moderate and high physical activity levels, respectively. The study findings are also consistent with findings by Moeini *et al.* (2011) in a study in Persia, where 64.9% of the patients did light-intensity or no physical activity, 29.8 % moderate physical activity and 5.3% of them did high intensity of physical activity. However, 35.1% in this study who engaged in moderate intensity exercise is low, compared to 59%, 52.5% and 64.4% reported by Qidwai and Azam (2004), Arcury *et al.* (2006) and Serour *et al.* (2007), respectively who had moderate physical activity. The study revealed that 94.5% of the respondents reported sedentary leisure time, which is in line with a study by Forghani *et al.* (2000), in which 90% of diabetic women reported sedentary leisure time. Prevalence of physical inactivity among the respondents in this study as 94.5% was higher than

(76.7%) physical inactivity reported by the Ghana STEPS Survey and 34.71% in Vietnam by Pham *et al.* (2009).

The low physical activity levels among diabetes patients is because those with diabetes often have physical disabilities (Gregg *et al.*, 2000), perceive discomfort when exercising or have decreased exercise capacity, compared to non-diabetic patients (Le Brasseur and Ruderman, 2005). Furthermore, the perception that diabetes 'weakened' and 'aged' the body appeared to have a de-motivational effect as far as physical activity was concerned (Lawton *et al.*, 2005). Similarly, decline in physical activity can be attributed to aging, as majority of the respondents were above 40 years, as documented in another study among middle-aged adults by Norman *et al.* (2002).

Physical activity levels showed significant relationship with incidence of CVD among diabetes patients in this study (Table 4.17). The results showed that CVD incidence was absent in those who engaged in vigorous intensity exercise, compared with those who did not exercise. This implies that exercising has an influence on CVD incidence among diabetes patients. Similar findings were reported by Manson *et al.* (1991) among postmenopausal women as walking briskly was associated with a 30% reduction in cardiovascular events. Regular physical activity has beneficial effects on incidence CVD, through regulating body weight, enhancing insulin sensitivity and glycemic control, and reducing blood pressure, atherogenic dyslipidemia, inflammation, fibrinolysis and endothelial dysfunction (Ross, 1999). Without a doubt, physical activity has been reported to improve the metabolic and cardiovascular risk of sedentary individuals (Swartz *et al.*, 2003, Murphy *et al.*, 2002). Studies by Gregg *et al.* (2003) and Hu *et al.* (2001) have shown walking to reduce CVD incidence or CVD mortality among persons with diabetes.

5.11 Alcohol Consumption

Table 4.16 shows 11.7% of the diabetic respondents were current drinkers, which is lower than the 32.5% and 30.5% in the general population reported by GSS (2009) and Ghana Health and ICF Macro Survey (2006) respectively. Alcohol consumption in the study is similar to studies in Los Angeles by Johnson (2001) which showed that alcohol consumption among diabetic patients was 18%. However, the observation from this study is different from alcohol consumption of 50.8% among diabetes patients in USA by Ahmed *et al.* (2006).

The rates of current drinking among diabetics in our study were lower than rates of current drinking in the general population (National Institute on Alcohol Abuse and Alcoholism, 2004). This curtailed alcohol consumption among diabetics observed in this study is likely due to the older age and declining health of respondents (Chartier and Caetano, 2009). Another reason may be due to the perceived dangers associated with alcohol abuse on medical therapy and its influence on disease progression and physicians' advice to limit alcohol intake (Zins *et al.*, 1999; Poikotainen *et al.*, 1996).

Majority of current alcohol drinkers in the study were male respondents. This is consistent with GSS (2009) findings, where 36.7% of men consume alcohol, compared to 17.5% of women. Peltzer and Ramlagan (2009), in their study also had similar findings in Mexico (77% males, 44% females) and Namibia (61% males, 47% females) that males consume more alcohol than females. In Western Africa, high alcohol abstinence has been reported among women in Senegal (97.7%), Mali (95.8%), and Ghana (63.0%) (Martinez *et al.*, 2011).The high intake of alcohol among male respondents can be attributed to the fact that in sub-Saharan Africa, alcohol

is seen as a symbol of power, hence considered something for males and traditionally not consumed by women (Willis, 2002).

However, alcohol consumption showed no significant relationship with CVD among diabetics. This can be due to the fact that moderate alcohol consumption is associated with increased insulin sensitivity (Facchini *et al.*, 1994; Kiechl *et al.*, 1996), hence reduction in the progression of diabetes complications. Alcohol consumption has been associated with a lower risk of CVD in individuals who are light to moderate drinkers (Mukamal *et al.*, 2010). Moderate alcohol intake is associated with increases in the level of HDL-C which is associated with reduced risk of cardiovascular disease (Cooper *et al.*, 2004) by consuming two drinks a day for men and one drink a day for women. There is a significant decrease in cardiovascular risk, due to the ability of alcohol to raise HDL and reduce fibrinogen (Mahan and Escott-Stump, 2008).

5.12 Blood Pressure

From Table 4.7, most diabetic respondents, had high blood pressure readings above 120/80 mmHg. This implies that the majority of diabetic patients do not have control of their BP. Blood pressure in patients with diabetes is known to be 1.5–3 times higher than in non-diabetics (Pacheco-Alvarez *et al.*, 2002).

The high blood pressure prevalence among diabetics in our study as 49.7% was lower than 64.1% diabetics with high blood pressure reported by Gudina *et al.* (2011) in Ethiopia. The proportion of diabetes patients (50.3%) who attained optimal blood pressure control was higher than 21% reported by Gu *et al.* (2013) in sub-Sahara Africa and 17% reported by Chineye *et al.* (2012) in Nigeria. This means compared with other sub-Sahara Africa countries, diabetics in Ghana had better control of their BP. Arterial hypertension is present in more than 60% of DM patients (Nilsson *et al.*, 2011). This is directly linked to increased renin-

angiotensinaldosterone system activity; hyperinsulinemia associated with increased renal reabsorption of sodium; and increased sympathetic tone (Narkiewicz *et al.*, 2009).

5.13 Diabetes Medications

According to Table 4.10, most respondents were on the combined oral medication (sulfonylureas and biguanides (mostly metformin), representing 46.9%. This may be ascribed to the poor glycemic control observed among diabetes patients in the study. Evidence suggest that combination therapy, using oral antidiabetic agents with different mechanisms of action is more effective in achieving and maintaining target blood glucose levels, as shown by poor glycemic control among respondents (CDA 2008, NIHCE 2005 and Weissman *et al.*, 2006). A combination of oral antidiabetic drugs is recommended if patients do not achieve a HbA1c level lower than 6.5% with monotherapy (CDA 2008, NIHCE 2005; Weissman *et al.*, 2006).

The majority of patients need multiple therapies to attain these glycemic target levels in the longer term. The fact that metformin combined with other oral medication were the most prescribed drugs complies with its endorsement as the preferred antidiabetic agent by current clinical guidelines (CDA 2008, NIHCE 2005; Weissman *et al.*, 2006). Metformin combined oral medication was the commonly prescribed anti-diabetic drug observed in the present study, which is in line with findings of Upadhyay *et al.* in (2007) and Johnson in (2006). This contrasts with the report of Sudha *et al.* (2008) that showed metformin as the most prescribed anti-diabetic medication.

5.14 Herbal Medications Usage among Diabetic Respondents

Table 4.10 reveals that 19.3% of those interviewed admitted using herbal remedies as part of their management of diabetes, whilst 80.7% admitted never to have used herbal medications as part of treatment. This finding in our study is consistent with 12.4% use of herbal remedies

observed by Mwangi and Gitonga in (2014). The results of herbal medication use of the study was however, lower than 65% reported by Dannemann *et al.* (2008) in Germany, 35.5% reported by Hasan *et al.* (2009) in Malaysia, 41.0% reported by Ceylan *et al.* (2009) in Turkey, among diabetics. However, herbal medication had no influence on the incidence of CVD among diabetes patients. Despite insufficient data on herbal medications safety and effectiveness, the fact remains that people with diabetes do and will continue to use herbal medications (Bastaki, 2005). The reason for the use of herbal medications among diabetics can be attributed to unwanted side effects such as allergic reactions, nutrients and drug-nutrient interactions, resulting in long-term adverse effects, arising from the use of conventional treatments (Palmer and Howland, 2001; Palmer and Betz, 2002; Halat and Dennehy, 2003).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, the prevalence rates of cardiovascular diseases; namely; hypertension, stroke and heart failure among diabetic patients were 66.2%, 8.28% and 3.45% respectively. Anthropometric data revealed prevalence of overweight and obesity as 42.8% and 22.8%, respectively, with central obesity prevalence of 61.38% and 65.5% for waist circumference and waist to hip ratio respectively. Dyslipidemia among diabetes patients showed prevalence of hypercholesterolemia, hypertriglyceridemia, low HDL-C and high LDL-C levels as 47.58%, 55.9%, 35.2% and 36.8%, respectively. Results on creatinine levels among diabetes patients revealed 18.6% had high creatinine levels.

Dietary habits among respondents showed inadequate vegetable and fruits intake among diabetes patients, low salt intake, high intake of saturated fats with no significant association of dietary intake with cardiovascular diseases ($p>0.05$) except salt intake which showed

significant association with cardiovascular disease incidence ($p<0.05$). The physical activity levels of participants revealed low levels of physical activity, as majority (61.4%) did not exercise, with significant association of exercise with cardiovascular disease incidence ($p<0.05$) among diabetics. Lifestyle of the respondents revealed most (91.0%) diabetics had never smoked before with few (9.0%) being ex-smokers, with significant association of smoking status with cardiovascular disease incidence ($p<0.05$) among diabetics. On alcohol consumption, of the subjects, 11.7% were currently drinking whilst 54.4% had never consumed alcohol, with no significant association of alcohol consumption with cardiovascular disease incidence ($p>0.05$) among diabetics.

The study further showed that risk factors such as gender, family history of stroke or heart failure, BMI, total cholesterol, fasting blood glucose, creatinine levels, fruit and vegetables intake and alcohol consumption had no significant association with cardiovascular disease incidence among diabetics.

Logistic regression analysis showed that independently, risk factors such as family history of hypertension, exercise, low salt intake and HDL-C levels are the only factors that had significant association with CVD among diabetes patients with p-values < 0.05.

6.2 Recommendations

In the light of the findings of this study, the following recommendations are made:

Further studies using cardiac profile assays, genetic analysis and other nutritional biomarkers such as sodium, potassium should be conducted to identify risk factors significantly associated with CVDs among diabetics.

Further studies using cohort studies on the predictive effects of total cholesterol, triglycerides and LDL should be conducted to identify the lipid profile parameters significantly associated with CVDs among diabetics.

Nutritional intervention for diabetes should emphasize weight management in order to prevent the development of CVDs among diabetics.

Routine public health education on the adequate consumption of fruits and vegetables should be organized by Regional/District health Directorates as the study showed inadequate consumption of fruits and vegetables.

Periodic monitoring of diabetic patients lipid profile, especially HDL-C levels should be integrated into the diabetes management program, to offset the incidence of CVDs.

The Ghana Health Service should consider establishing health facility-based CVD screening programs among diabetics, especially among those with family history of hypertension.

Studies should be conducted on the usefulness of nutritional counselling and education in nutritional management of diabetes patients.

Health care practitioners, especially doctors and dieticians should be encouraged to intensify diet prescription and lifestyle modification for individuals with CVDs especially among diabetics, to help them limit or avoid certain foods.

6.3 Limitations and Further Research

There were several limitations to the current study:

No cause-effect relationship can be inferred from cross-sectional data. The cross sectional design of the study may underestimate the true effects, as data obtained was from patients' ability to recall. Cohort or prospective studies are needed to identify relationships between risk factors and CVDs among diabetics.

Biases and sampling challenges occurred due to time constraints and patients not willing to consent. This might have caused challenges in establishing relationship between risk factors and CVDs.

Due to time constraint and some hospitals unwillingness to permit their facility to be used for the study we therefore used facilities which did not have diabetic or hypertensive clinics. This affected sampling and proportional distribution of cases and control in the study.

Among respondents, waist circumference was measured with their dresses on, as it was difficult to get a separate room for measurement of their waist. This is likely to cause a variation in WC measurements and WHR of respondents.

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APPENDIX

QUESTIONNAIRE FOR: IMPACT OF NUTRITIONAL STATUS ON THE PREVALENCE OF CARDIOVASCULAR DISEASE AMONG DIABETES MELLITUS IN GHANA IDENTIFICATION NUMBER.....……

FOLDER NO…… DATE……..... (DD/MM/YYYY) TIME……. (HH:MM)

PLEASE TICK [√] OR CIRCLE AS APPROPRIATE

OBJECTIVES:

1. To assess the anthropometric data of diabetes mellitus patients
2. To determine the prevalence of dyslipidemia among diabetes mellitus patients
3. To assess the dietary intake of diabetes mellitus patients
4. To assess the physical activity level of diabetes mellitus patients
5. To determine prevalence cardiovascular disease in diabetes mellitus patients

SECTION A: DEMOGRAPHICS CHARACTERISTICS

1. Age ……

2. Gender
   a. Male
   b. Female

3. Highest Educational Level
   a. No formal Schooling
   b. Basic School
   c. SSS/A Level completed
   d. Tertiary completed
   e. Other (Specify): ……
4. Employment status
   a. Employed
   b. Unemployed
5. Type of employment……
6. Residence:
   a) Urban
   b) Semi
   c) Rural
7. Ethnicity:
   a) Akan

b) Ewe
c) Ga
d) Hausa
e) Grussi
f) Dagbani

g) Others Specify……..

8. Marital status:

a) Single b.) Married c.) Separated d.) Divorced e.) Widowed

9. Level of income:…….

10. How do you pay your medical bill?
    a) Self
    b) Relatives
    c) Employer
    d) NHIS
    e) Others specify……

SECTION B: DIETARY HABITS

11. How many times do you usually eat your main meal in a day?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice [ ] 12. What meals do usually prepare at Home?
    a) Breakfast [ ] b) Lunch [ ] c) Supper [ ] d) Nil [ ] 13. How many times do you usually take snacks in a day?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice [ ] e) Nil [ ]
14. In a typical week how many days do you take fruits?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice [ ] e) Nil [ ] 15. How many times do you usually take fruits in a day?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice [ ] e) Nil [ ] 16. When do you eat fruits in a day?
    b) Morning [ ] b) Afternoon [ ] c) Evening [ ] d) Nil [ ] 17. In a typical week how many times do you take vegetables?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice e) Nil [ ]
18. How often do you eat vegetables in a day?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice[ ] e) Nil What type of oil/fat is often used for meal preparation in your household?

a) Vegetable oil (unsaturated) olive/sunflower/soyabean [ ]
b) Non vegetable oil (saturated) palm oil/ frytol/ coconut oil name……

19. Do you add salt to food when cooking? a) Yes [ ] b) No [ ] **If no go to question 23**
20. Which of the following best describes your salt intake?
    a) Low [ ] b) Moderate [ ] c) High [ ]

21. Do you add table salt to already served meal cooked food at table? a) Yes [ ] b) No [ ]
22. How often do you consume canned foods?
    a) Never b) Daily [ ] c) Weekly [ ] d) Monthly [ ] e) Occasionally [ ]

SECTION C: PHYSICAL ACTIVITY

23. How often do you exercise in a day?

a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than Thrice [ ] e) Nil [ ]

25. What type of exercise do you do?

a.) vigorous-intensity e.g. running, basketball, bicycling, swimming and football

b) moderate-intensity (slow dancing, brisk walking, bicycling at a regular pace or table tennis)

24. In a typical week, on how many days do you do exercise state No. of Days

a) One day [ ] b) Two days [ ] c)Three days [ ] d) Four days [ ] e) All days [ ]

25. How much time do you spend exercising On a typical day? Number of hr / min: …
26. Does your work involve vigorous-intensity activities (e.g. chopping wood, lifting heavy loads, farming, digging or construction work) that causes large increase in breathing or heart rate for at least 10 minutes continuously?
    a) Yes [ ] b) No [ ]
27. In a typical week, on how many days do you vigorous- intensity activities (e.g. carrying light loads, gardening/yard work) as part of your work? […….]
28. How long do you spend doing vigorous-intensity activities on a typical day? [……..]
29. Does your work involve moderate-intensity activities (e.g. carrying light loads, gardening/yard work) that causes small increase in breathing or heart rate for at least 10 minutes continuously?
    a)Yes [ ] b) No [ ]
30. In a typical week, on how many days you do moderate-intensity activities exercise (e.g. carrying light loads, gardening/yard work) as part of your work?.....
31. How long do you spend doing moderate-intensity activities on a typical day? [……]
32. Do you walk or use a bicycle for at least 10 minutes continuously to get to and from places? Yes [ ] No [ ]
33. In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places? Number of days [ ]
34. How much time do you spend walking or bicycling for travel on a typical day? Hours : minutes
35. How much time do you usually spend sitting or reclining on a typical day? Number of hr / min ……

SECTION D: FAMILY AND MEDICAL HISTORY

36. Does any member of your family have Diabetes Mellitus?
    a) Yes [ ] b) No [ ] c) Don't know [ ]

37. If yes, how do you relate to the person? .....
38. Does your family know about your condition Diabetes? a) Yes [ ] b) No [ ] c) Don't know [ ]
39. If yes, do you receive any support from them? a) Yes [ ] b) No [ ]
40. How long have you been diagnosed with diabetes? ...……..
41. Do you currently use any form of diabetic medication? a)Yes [ ] b) No [ ]
42. If yes which of these do you use?

a) Glineperide only
b) Metformin only
c) Glibenclamide only
d) Insulin only
e) Glibenclamide and Metformin
f) Gliclazide and Metformin
g) Insulin with oral medication
h) Others specify.....

43. If yes how long have you been using it? .....
44. Are you using any herbal medication?
a) Yes [ ] b)No [ ]
If yes how long? …… **CO-MORBIDITY**
45. Do you have any of these diseases?
a) Hypertension [ ] b) Stroke [ ] c) Heart failure/attacks
c) If others, state type .....
46. When was/ were these diseases diagnosed?

a. Stroke ……where…….
b. Heart failure/attack …….....where .....
c. Hypertension …… where……

47. Are you on any medication for any of these diseases?
48. If yes state the medication.....
49. Duration of treatment……

LIFE STYLE: SMOKING STATUS

50. Which of the following best describes your smoking status?
a) Never smoked [ ] b) Current smoker [ ] c) Ex-smoker [ ]
If never smoked go to 56, if ex-smoker go to 55
51. Do you smoke any of the tobacco products? Such as pipes or cigarettes daily? a)Yes [ ] b)No [ ]
52. If yes, how long have you been smoking? .....
53. What is the average number of cigarettes Smoked per day? ……
54. If you quit for how many years did you smoke? .....

LIFE STYLE: ALCOHOL CONSUMPTION

55. Which of the following best describes your drinking status?

a) Never drink [ ] b) Current drinker [ ] c) Ex –drinker [ ] **If never drink skip to FFQ checklist, if ex-drinker go to 61**

56. How long have you been drinking? ..... …… 57. How many bottles do you drink in a day?
    a) Once [ ] b) Twice [ ] c) Thrice [ ] d) More than thrice
58. Have you consumed alcohol such as beer, wine, spirits akpeteshi, palm wine, pito, fermented cider, other alcoholic bitters or any other drink within the past seven days?
    a) Yes [ ] b) No [ ]
59. In the past 3 months, how frequently have you had at least one drink?

a) Nil [ ] b)Daily [ ] b) 5-6 dys per week [ ] c) 1-4 dys per week [ ] d)1-3 dys per month [ ]

60. Which of the following describes your drinking pattern?
    a) Daily [ ] b) Weekly [ ] c) Monthly [ ] d) Occasionally [ ]
61. What age did you quit drinking? ……..

SECTION F: ANTROPOMETRY AND MEASUREMENT

ANTHROPOMETRY	READING	UNIT
Weight		
Height		
Waist circumference		
Hip circumference		
BODY COMPOSITION		
Percentage body fat		
Visceral fat		
BLOOD PRESSURE		
Systolic		
Diastolic		
LIPID PROFILE		
Total cholesterol		
Triglycerides		
High density lipoproteins		
Low density lipoproteins		

FOOD FREQUENCY CHECKLIST

I am going to read out a list of various foods. Please tell me how many times you eat them on an average every week.

High Fibre Starches	Daily	3-5 times per week	Weekly	Monthly	Occasionally	Never
Oats						
Tom brown/weanimix						

Wheat bread/Wheat						
Kenkey						
Others						
Low Fibre Diets						
Banku						
Fufu						
Konkonte						
Plain rice/Rice balls						
Waakye						
Sugar bread						
Tea bread						
Butter bread						
Boiled plantain						
Boiled ripe Plantain						
Boiled yam						
Gari						

Hausa koko						
Koko (corn)						
Tuo-zaafi						
Others						
Fatty Foods						
Fried yam						
Fried ripe plantain with beans and oil						
Jollof rice						
Fried rice						
Fried egg						
Fried fish						
Fried chicken without skin						
Fried meat						
Cream milk						
Groundnut soup						
Palm soup						
Cheese						
Butter/Margarine						
Meat pie/doughnut/ rock buns						
Others						
Foods high in saturated fats and cholesterol						

Fried chicken with skin						
Grilled/boiled chicken with skin						
orphals						
Crabs						
Shrimps						
Domedo						
Others						
Foods Low in Saturated Fats and Cholesterol						
Grilled/boiled chicken without skin						
Smoked/Grilled fish						
Boiled egg						
Skimmed meat						
Cooked lean meat						
Others						
Nuts And Seeds						
Cooked beans						
Roasted Groundnuts						

Roasted cashew nuts						
Agushie						
Others						
High Sodium Foods						
Kobi						
Kako						
Salted pig feet						
Toolo beef						
Momoni						
Sardine						
Corned beef						
Maggi						
Jumbo						
Royco						
Onga						
Tinned vegetable salad						
Others						
Fruits						

Pawpaw						
Orange						
Mango						
Banana						
Water melon						
Pineapple						
Apple						
Others						
Vegetables						
Cabbage						
Carrot						
Cucumber						
Fresh tomatoes						
Kotonmire						
Garden eggs						
Okro						
Bra						
Ayoyo						
Pumpkin leaves						
Alefu						
Bitter leaf						
Foods High in Refined Sugar						
Coca cola						
Biscuits						
Cakes						
Sprite						
Fanta						
Sugar cane						
Don Simon/Ceres Minute maid/ etc.						
Malt						
Others						
Alcoholic Beverages						
Bear						
Guinness						
Spirit						
Wine						
Punch						
Others						