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**PREVALENCE OF TYPE II DIABETES AND ITS RISK FACTORS AMONG  
THE LUO AND THE KIPSIGIS OF THE LAKE VICTORIA BASIN**

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**REG NO: H87/10655/07**

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**MAY, 2011**

Kiplamai, Festus  
*Prevalance of type II  
diabetes and its risk*



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## DECLARATION

This thesis is my original work and has not been presented for a degree or diploma in any other university or institution. To the best of my knowledge, this Thesis contains no material previously published or written by another person, except where due reference is made in the text.

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**DEDICATION**

This thesis is dedicated to my lovely boys Vincent Kipruto and Ryan Kipchumba for their patience and encouragement throughout the process of collecting data, analysis and thesis writing. I also dedicate this work to my dear wife Milcah Kiplamai for her support and persistent encouragement especially during the times I had hit the rock bottom.

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**ABBREVIATIONS AND ACRONYMS**

ACSM	American College of Sports Medicine
ADA	American Diabetis Association
AEE	Activity Energy Expenditure
BMI	Body Mass Index
BMR	Basal Metabolic Rate
CBS	Central Bureau of Statistics
CHD	Coronary Heart Disease
CHO	Carbohydrate
Chol	Cholesterol
CVD	Cardiovascular Disease
DHA	Docosahexaenoic acid
EPA	Eicosapentaenoic Acid
FBG	Fasting Blood Glucose
GLV	Green Leafy Vegetables
GPAQ	Global Physical Activity Questionnaire
HC	Hip Circumference
HDL	High Density Lipoproteins
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
IPAQ	International Physical Activity Questionnaire
Kcal	Kilocalories
KDHS	Kenya Demographic and Health Survey
KNBS	Kenya National Bureau of Statistics
LDL	Low Density Lipoproteins

LVB	Lake Victoria Basin
METS	Metabolic equivalents
MUAC	Middle Upper Arm Circumference
NCD	Non-communicable disease
O3FA	Omega 3 Fatty Acids
OGTT	Oral Glucose Tolerance Test
PAL	Physical Activity Level
REE	Resting Energy Expenditure
RMR	Resting Metabolic Rate
SHR	Sleeping Heart rate
T2D	Type 2 Diabetes
TG	Triglycerides
WC	Waist Circumference
WHO	World Health Organization

**ABSTRACT**

The prevalence of Type II Diabetes (T2D) in developing countries is increasing at a high rate. The purpose of this study was to assess the modifiable predictors of T2D and variations in predisposing factors among the people living around Lake Victoria region, and in particular to describe variations in dietary factors, physical activity, socio-economic status and prevalence of T2D among two rural communities in the lake Victoria basin. A cross-sectional survey design was used for randomized selection of the subjects from the two rural populations. The total number of subjects recruited was 304 (134 males and 170 females) to fulfill the 95% confidence level required for comparisons. Data were analyzed using ANOVA and T-test, where applicable, for comparison of means between groups and chi square to show associations between variables. There was no significant difference in the mean age of the two populations thus age was not a confounding factor. The overall prevalence of T2D in the rural areas represented by the sample was found to be 2.3% of the population (3.0% and 1.8% among males and females respectively). The overall prevalence of IGT in the rural areas was at 8.1% (CI: 5.0-11.2) of the total population {3.1% (CI: 0.2-6.0) and 11.3% (CI: 6.3-15.7) among the males and females respectively}. There was significant differences in the BMI between the males and females ( $p < 0.001$ ). The females had a significantly higher BMI than the males. The Body Mass Index (BMI) ( $p = 0.003$ ), %BF ( $p = 0.002$ ), and HC ( $p = 0.004$ ), differed significantly among glucose intolerant and the normal individuals. There were large cross-ethnic differences in dietary intake among the two populations. Glucose intolerant (GI) subjects were found to have a significantly ( $p = 0.017$ ) lower percentage of protein (12%) intake in their diets than the control (14%). There were no significant differences in the time reported spend on vigorous physical activities among the two populations. The total Metabolic Equivalent (MET) values were also found to be significantly lower ( $p < 0.001$ ) among the Kipsigis compared to the Luo community. The amount of time spend sitting was found to be significantly ( $p < 0.001$ ) higher among the Luo as compared to the Kipsigis in both gender. There were no significant differences in the metabolism of glucose between the different blood types across the two communities. The levels of triglycerides was found to be significantly associated ( $\chi^2 = 25.21$ ,  $p < 0.001$ ) with increased incidence and prevalence of T2D and its risk factors among the Luo while this was not true for the Kipsigis community. The Cholesterol ( $\chi^2 = 89.42$ ,  $p < 0.001$ ) and the LDL ( $\chi^2 = 16.82$ ,  $p = 0.032$ ) were similarly associated with the prevalence of T2D and risk markers among the Luo only. In conclusion, the highly significant differences in prevalence of T2D and its risk marker are related mainly to differences in lifestyle, with a special emphasis on dietary patterns. Elevated BMI, % BF, HC, Chol, and LDL independent of age and sex are risk factors for glucose intolerance. The increased amount of time spend sitting as a proxy indicator for physical inactivity is a risk factor to T2D and its risk markers. It is recommended therefore that they should manage their diet intake and physical activities very closely to avoid being predisposed to T2D, IGT and elevated blood sugar levels.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background of the Problem

Diabetes mellitus is a metabolic disorder characterized by chronic hyperglycemia with disturbances in carbohydrate, fat and protein metabolism, arising from a defect in insulin secretion or action or both (American Diabetic Association (ADA), 2003). Insulin regulates carbohydrate metabolism by increasing glucose transport, phosphorylation, glycolysis and glycogen synthesis while decreasing gluconeogenesis and glycogen breakdown. It also regulates fat metabolism by increasing synthesis and storage of fatty acids and triglycerides while decreasing lipolysis and fat metabolism. Further it regulates protein metabolism by increasing amino acid uptake and protein synthesis (Dunstan, Zimmet, Welborn, Courten, Cameron, Sicree, Dwyer, Colagiuri, Jolley, Knuiman, Atkins and Shaw, 2002).

The prevalence of Type 2-Diabetes mellitus (T2D) in developing countries is increasing at an alarming rate (Wing, Goldstein, Acton, Birch, Jackicic, Sallis, Smith, Jefery and Surwit, 2001). This has been attributed to changes in diet and physical activity on the background of genetic pre-disposition (Bhargava, Sachdev, Fall, Osmond, Lakshmy, Barker, Biswas, Ramji, Prabhakaran and Reddy, 2004). The increase in prevalence is associated with the aging of the population, the dramatic increase in prevalence of obesity and more sedentary lifestyle (Wing *et al.*, 2001). Many developing countries in Africa and Latin America are beginning to experience a rise in the prevalence of T2D as well, which is likely to further burden the already strained healthcare systems of these countries (Schulz, Bennett, Ravussin, Kidd R, Kidd K, Esparza and Valencia, 2006). T2D remains an elusive disease which is on the

rise both in developing and developed countries. Mogensen and Zimmet (2002) estimated that the people who will be affected by T2D would increase from 150 million in 2002 to 300 million people by 2025.

Type 2 Diabetes accounts for approximately 95% of all diabetic cases in Africa and it occurs at any age although it is common above the age of 40 years (Amoah *et al.*, 2002). However, the risk factors for developing T2D in Africa seem to be different from those seen in industrialized countries. In Africa, T2D seem to be predominantly characterized by low insulin production as opposed to insulin resistance and obesity (Dunstan *et al.*, 2002). As such, there is a need to identify the risk factors for T2D in Africa in order to develop recommendations for suitable preventive and treatment interventions in life-style changes and insulin treatment.

The occurrence of disturbed glucose and insulin metabolism, overweight and high abdominal fat distribution, mild dyslipidemia and hypertension and its association with subsequent development of T2D has given rise to the concept of metabolic syndrome also known as insulin resistance syndrome (Dunstan *et al.*, 2002). Metabolic syndrome is the presence of Impaired Glucose Tolerance (IGT) or T2D and at least two of the following: abdominal obesity (waist- hip ratio  $> 0.90$  or BMI  $\geq 30\text{kg/m}^2$ ) hypertension ( $\geq 160/90$  mmHg), dyslipidemia (Serum triglycerides  $\geq 1.7\text{mmol/l}$ ) (Dunstan *et al.*, 2002). Impaired  $\beta$ -cell function can be due to selective insensitivity to glucose, loss of first phase insulin secretion, genetic defects in glucose regulation and insulin processing, or reduced number of  $\beta$ -cells. Insulin resistance (IR) defined in terms of insulin-mediated glucose uptake in the muscle is associated with hyperinsulineamia and obesity although IR and hyperinsulineamia predict the

development of type 2 diabetes independent of body weight (Obel, 1988). This has been demonstrated in Ghana where low body mass indices have been observed despite a higher metabolism of carbohydrate for energy, while impaired fasting glucose (IFG) and T2D patients exhibit severe beta cell dysfunction, insulin resistance, and elevated triglycerides (Banini *et al* 2003). Excess adipose tissue causes IR by increasing delivery of non-esterified fatty acids (NEFA) to the liver and muscle and enhances production of catabolic hormones. Physical inactivity and obesity are risk factors for diabetes and the reduction or elimination of such factors appears to be related to prevention and management of T2D (Wing *et al.*, 2001).

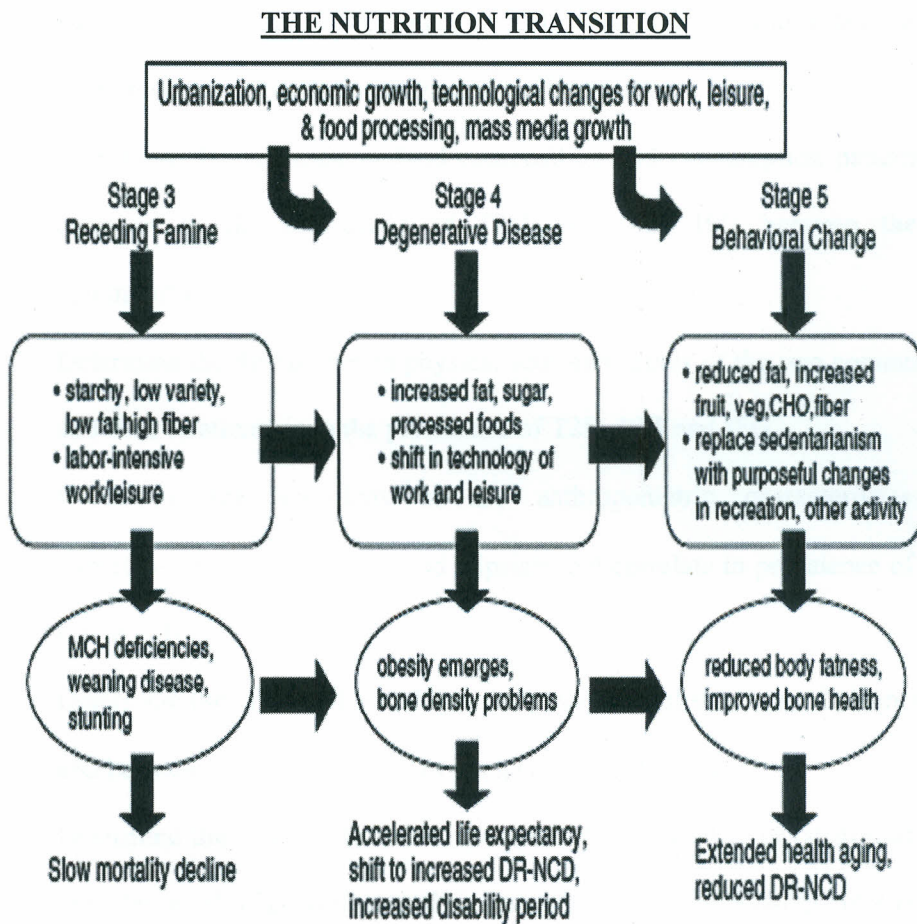
Urbanization is a risk factor for diabetes and is reflected in some studies as insignificant because of the degree to which rapid overall urbanization is affecting rural lifestyle (Christensen, Friis, Mwaniki, Kilonzo, Tetens, Boit, Omondi, Kaduka and Borch-Jonsen, 2009). Age is an important and significant risk factor for T2D and those above 65 years showing the highest age-related prevalence. Adiposity measures are highly associated with T2D with many studies showing increase in prevalence with increase in BMI. The prevalence of obesity was highest in the diabetic patients viz a viz the non-diabetics (7.7% vs 2.2% in Sudan; 9.1% vs 3.7% in Tanzania and 65% vs 25% among the Urban Zulu of Durban South Africa) (Motala 2003).

## **1.2 Statement of the Problem**

Currently diabetes is the 10<sup>th</sup> leading cause of death in East, Central and Southern Africa with T2D accounting for 85 - 95% of all the cases (WHO, 2003). There is a need for diabetes care in Kenya to address specific background information on lifestyle variations and the social-economic constraints in various communities.

Although the exact genetic markers of T2D remains unknown in Kenya, studying subjects from same environment will contribute to our understanding of the environmental mediators favouring the increasing prevalence of this disease. There is paucity of information about the prevalence of T2D and its risk factors within and between the rural populations of the Lake Victoria Basin in Kenya.

### 1.3 Conceptual Framework



Adopted from: Popkin BM and Gordon-Larsen (2004)

#### **1.4 Purpose of the Study**

The purpose of this study was to determine the prevalence of T2D and its risk factors in relation to physical activity and dietary practices among the Luo and the Kipsigis of the lake Victoria Basin

#### **1.5 Objectives of the Study**

The objectives of this study were to;

1. Determine variation in prevalence of T2D, IGT and IFG within and between the two communities living in the same climatic area.
2. Determine the variation in food composition and consumption patterns and correlate to the prevalence of T2D, IGT and IFG between the two communities.
3. Determine the differences in physical activities levels of the two communities and their relationship to the prevalence of T2D, IGT and IFG.
4. Determine the variations in the anthropometric characteristics and hypertension among the Luo and Kipsigis and correlate to prevalence of T2D, IGT and IFG.
5. Determine the effects of blood type on post-prandial sugar metabolism within and between two communities of the lake Victoria Basin.
6. Determine the differences in the lipid profile as related to physical inactivity, prevalence of T2D, IGT and IFG among the Luo and Kipsigis of the Lake Victoria Basin.

## 1.6 Research Hypotheses

- Ho<sub>1</sub> There are no significant differences in the prevalence of T2D, IGT and IFG within and between the Kipsigis and Luo communities.
- Ho<sub>2</sub> There are no significant differences in the food consumption patterns with regard to the prevalence of T2D between the two communities.
- Ho<sub>3</sub> There are no significant differences in the physical activities and socio-economic status of the Kipsigis and Luo communities and its effects on T2D.
- Ho<sub>4</sub> There are no significant differences in the BMI, %body fat and hypertension among the Kipsigis and Luo communities
- Ho<sub>5</sub> There are no significant differences in post-prandial sugar metabolism among people of different blood types within and between two communities of the lake Victoria Basin
- Ho<sub>6</sub> There are no significant differences in the lipid profile of the Luos and Kipsigis of the Lake Victoria Basin.

## 1.7 Significance of the Study

The most potent currently recognized environmental risk factors for T2D are diet, physical activity and obesity; all modifiable through behavioural intervention. Clinically, early detection of diabetes provides an opportunity to reduce the progression of micro-vascular or macro-vascular diseases caused by asymptomatic hyperglycemia. The risk of progression to T2D from IGT and IFG can be reduced through improved metabolic control and reduction of key risk factors over time. This approach could then greatly improve the prognosis for diabetic patients. In addition, increased prevalence of the disease is a burden to the health care services due to the

rising numbers and degenerating conditions of affected individuals who require long-term treatment and support. Additionally, physical activity is an underutilized mode of therapy for T2D often due to lack of understanding of its prophylactic effects. The direct medical costs of diabetes are significant while indirect costs of the disease accrued through loss of economic productivity to society can be even larger and will only increase further with the downward shift in age of onset. There is also scarcity of data on prevalence of T2D and its risk factors in the Kenyan populations despite the alarmingly predicted increase in T2D. There is therefore need for more studies in this field, which could then provide important information that will lead to novel preventive strategies to help reduce the prevalence of T2D in developing countries in general and Kenya in particular.

### **1.8 Delimitation of the Study**

This study was delimited to the adults from the Luo and Kipsigis communities meeting the inclusion criteria. The sample size was delimited to 150 per community to satisfy the 95% confidence level required as determined using G-power analysis software. The study was also delimited to one season of one year only thus differences in seasons and within years were not found out. Findings can therefore not be generalized for all the climatic seasons of the year because it was only done during the advent of the short rains in August. Another delimitation is that the subjects should adhere to fasting the night before participating in the study.

### **1.9 Assumptions of the Study**

This study assumed that the subjects maintained their normal daily routine patterns during the study period. It also assumed that the random selected subjects resulted in a

normal distribution as regards prevalence of T2D. Further, it assumed that the responses from the subjects were truthful concerning their dietary intake and physical activities.

### 1.10 Operational Definition of Terms

**Basal Metabolic Rate:** Energy expended in the rested and fasted state. It requires about 60-70% of total energy use by the body.

**Body Mass Index (BMI):** A simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilogrammes divided by the square of the height in metres ( $\text{kg}/\text{m}^2$ ).

**Diabetes Mellitus:** A chronic metabolic condition exhibiting elevated blood glucose levels

**Dietary intake:** Qualitative and Quantitative measurement of the food and fluids ingested by an individual

**Exercise:** A specific type of physical activity that includes any planned, structured, and repetitive bodily movement done specifically to improve and maintain one or more components of physical fitness

**Genotype:** This is stored information used as a "blueprint" or set of instructions for building and maintaining a living creature

**High Density Lipoproteins:** The 'good cholesterol' -a complex of lipids and proteins in approximately equal amounts that functions as a transporter of cholesterol in the blood. High levels are associated with a decreased risk of atherosclerosis and coronary heart disease.

- Kipsigis:** This is a Nilotic population living in the Lake Victoria basin and are mainly agro-pastoralists.
- Lake Victoria Basin:** The area surrounding Lake Victoria in Kenya having the same climatic patterns.
- Low Density Lipoproteins:** The 'bad cholesterol'- A complex of lipids and proteins, with greater amounts of lipid than protein that transports cholesterol in the blood. High levels are associated with an increased atherosclerosis and coronary heart disease
- Luo:** They are a nilotic population living in the Lake Victoria Basin and practice mainly fishing as the main economic activity.
- Metabolic Syndrome:** A set of signs and symptoms that include elevated triglycerides, reduced HDL, elevated blood pressure, elevated glucose and abdominal obesity
- Nutrition Transition:** The changing patterns in a population's nutrition status whereby rates of under nutrition decrease and the rates of over nutrition increase through stages in which under nutrition and over nutrition can be found in the same household
- Obesity:** A condition of abnormal or excessive fat accumulation in adipose tissue, such that health may be impaired
- Overweight:** A condition where the person has excess weight for his corresponding height. A Body Mass Index (BMI) of 25 to 29.9 is considered overweight.

**Phenotype:** This is the "outward, physical manifestation" of the organism and anything that is part of the observable structure, function or behavior of a living organism.

**Physical activity:** Any bodily movement produced by skeletal muscles that result in a substantial increase over the resting energy expenditure. It encompasses structured leisure time activity such as exercise and sports, as well as occupational work, household chores, and other activities of daily living.

**Physical inactivity:** A state when body movement is minimal and energy expenditure approximates RMR.

**Resting energy Expenditure:** The energy expended by the body in the resting state to maintain itself and digest food.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter presents a review of literature related to physical activity, dietary intake and the prevalence of Type 2 Diabetes (T2D). It focuses on the prevalence of T2D, physical activity/exercise and dietary factors. It concludes with a summary of the literature directly connecting to the statement of the problem.

#### 2.2 Prevalence of Diabetes

The prevalence of diabetes for all age groups worldwide was estimated at 2.8% in 2000 and predicted to reach 4.4% in 2030 (Wild *et al.*, 2004). The prevalence of diabetes in African communities is increasing with ageing of the population and lifestyle changes associated with rapid urbanization and westernization (Wild *et al.*, 2004). The World Health Organization (WHO) expects 150 million new diabetic cases by 2025, of which 70% is expected to occur in the developing world (King and Rewes, 1998). The global prevalence of diabetes in the 20 – 79 years age range in 2003 was estimated to be 5.1% (King and Rewes, 1998), but the prevalence varied dramatically by region and race (Bhargava *et al.*, 2004). Rural areas of developing countries have low prevalence of T2D but in many countries prevalence is increasing rapidly due to increasing urbanization and aging population (Christensen *et al.*, 2009). Prevalence is much higher in some ethnic groups than others in the same environment or country.

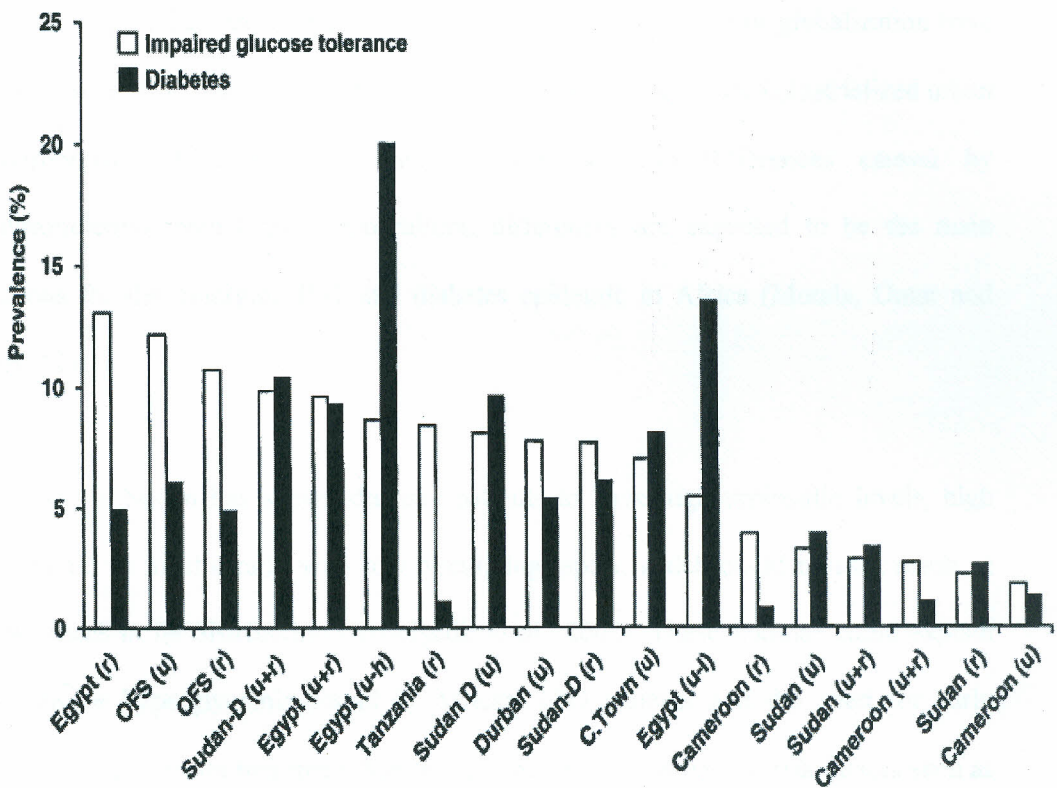
These observations together with strong evidence of the importance of genetic susceptibility in T2D indicate that the disease results from an interaction between

genetic predisposition and lifestyles associated with unfavourable environments (Schulz *et al.*, 2006). Type 2 Diabetes has both genetic and environmental determinants. Despite geographic separation, language variations and current genetic distance, estimates show that people who share very similar genetic background carry similar diabetes and obesity susceptibility genes (Schulz *et al.*, 2006).

### **2.2.1 Diabetes Trends in Africa**

The global epidemiology data on T2D indicate that the greatest increases in prevalence and total affected population can be expected to occur in developing countries, with the prevalence rate projected to increase by 48% (from 3.3% to 4.9%) by the year 2025 (King *et al.*, 1998). This increase is expected to amount to a 170% increase in the number of individuals with T2D in developing countries, from 84 to 227 million (WHO 2003). Separate projections for sub-Saharan Africa are for an 18% increase in prevalence rate (from 1.1% to 1.3%), which is expected to yield a 185% increase in the number of individuals with diabetes, from 3 to 8 million. In 1950, 32 million people lived in urban areas of Africa, by 2025 an estimated 857 million people or 54% of the total African population, will live in urban areas (Sobngwi *et al.*, 2001; King and Rewes 1998). The first cases of diabetes in Africa were reported in the late 1950s in South Africa and Ghana urban dwellers, while diabetes was nearly absent in rural dwellers. While this rural-urban discrepancy in diabetes prevalence could not be found in Tanzania, the prevalence of IGT was 30% higher in urban settings compared to rural areas. Studies in Africa show diabetes prevalence to be much higher in urban than rural areas, with subjects demonstrating elevated blood pressure and triglycerides levels (Christensen *et al.*, 2009).

Current evidence suggests that environmental factors are the major determinants of the increasing rate of diabetes. Differences in distribution of risk factors and disease between race and ethnic group are said to be a function of the frequency of specific genotypes and interaction with environmental factors (Kuller 2004; Gharbi, Akrouf Motala, Omar and Pirie 2003 and Zouari 2002). In Egypt, the prevalence of obesity, diabetes mellitus and hypertension is high following urbanization (Fig.2.1) that results in a nutrition transition in the context of abundant dietary energy availability and moderate fat intakes (Galal, 2002).



(Source: Adopted from Galal, 2002)

**Figure 2.1: Relationship of IGT and T2D prevalence**

A high intake of dietary fibre protects against T2D, and increased physical activity helps reduce the risk of developing T2D by preventing IR (Matsuda and Ralph 1999). An interaction effect has been found between diabetes, obesity and total fish and seafood consumption, with increased consumption reducing the risk of T2D in populations with a high prevalence of obesity (Nanri, Mizoue, Yoshida, Takahashi and Takayanagi, 2008). Studies have shown basal and glucose/glucagons-stimulated C-peptide levels in T2D Africans to be lower in comparison to those reported in Caucasians, East Indians, and African Americans (Ahren *et al.*, 1998; Siraj *et al.*, 2002). Cultural factors and social changes have also been shown to contribute more to the etiology of T2D than ethnic origins. Socio-economic forces of globalization have seen change from traditional lifestyle and dietary patterns to more industrialized urban environments. Life-style (diet and physical activity) differences caused by environmental factors and socio-cultural differences are expected to be the main reasons for the emerging IGT and diabetes epidemic in Africa (Motala, Omar and Pirie 2003).

A study in Sudan has shown diabetic patients to have high proinsulin levels, high proinsulin to insulin ratio with low circulating leptin, which could be as a result of differences in fat distribution (Abdelgadir *et al.*, 2002). These findings could explain the severe hyperglycemia found in African T2D patients and the need for early diagnosis and insulin treatment. Metabolic syndrome is a cluster of risk factors such as central obesity, dyslipidemia, glucose intolerance, hypertension and insulin resistance. Data from the Nurse's Health Study (United States of America) in 2001 suggested that the lower risk of diabetes occurs in individuals who have a BMI <21, with increasing prevalence seen with increasing obesity levels. Similarly, there is a dose-response

relationship between physical activity and risk of diabetes (Wing *et al.*, 2001). However, exercise alone has been found not to significantly reduce glycated haemoglobin levels (Van *et al.*, 2004)

### 2.2.2 Diabetes Trends in Europe

Type 2 Diabetes trends are on the increase in Europe as reported in various studies (Gatlin *et al.*, 1996; Berger *et al.*, 1999) except for Iceland whose prevalence has been stable for the past 20 years. In France the estimates of Diabetes (Type 1 and Type 2) stands at between 1.5 – 3.0 million people. These findings may be attributed to the improved diagnostic criteria, early diagnosis and improved survival of patients of a combination of these factors. Amos, McCarty and Zimmet (1997) estimated the prevalence of type 2 diabetes for the years 1995 and 2000 for the seven European countries selected (Table 2.1). Specifically, Amos *et al* (1997) predicted a moderate decrease in T2D prevalence in Finland and a moderate increase in Denmark and Spain. They however predicted a significant increase in T2D in the UK, Germany, Italy and France as shown in Table 2.1.

**Table 2.1: Estimates and projections of T2D prevalence in Europe**

Country	Population	1995	2000	2010
Finland	5,100,000	243,000	237,000	238,000
Denmark	5,200,000	171,000	195,000	241,000
UK	58,000,000	1,076,000	1,863,000	2,880,000
Germany	81,000,000	2,715,000	3,353,000	4,244,000
Italy	57,000,000	2,635,000	2,824,000	3,172,000
Spain	39,500,000	1,652,000	1,744,000	1,859,000
France	58,000,000	1,147,000	1,880,000	2,784,000

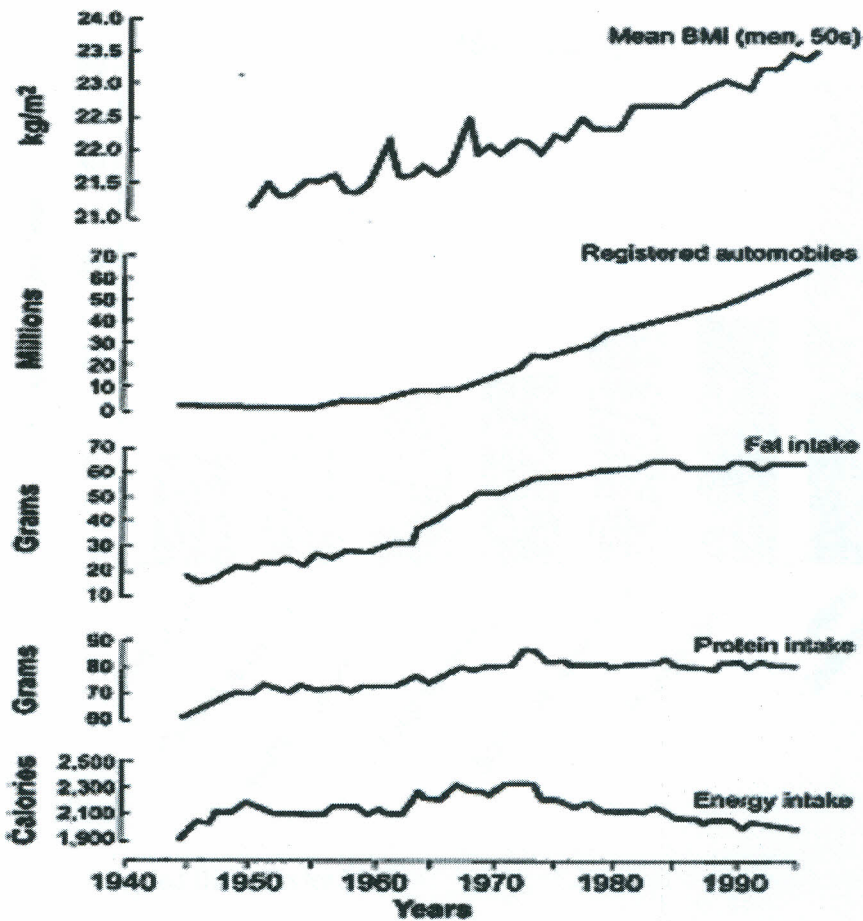
Source: Adopted from Amos *et al.*, 1997

### **2.2.3 Diabetes Trends in Japan**

The prevalence of diabetes is increasing in Japan, and it is estimated that more than 12 million Japanese people are hyperglycemic. This high prevalence is most likely the result of a complex interplay between genetic and environmental factors specific to Japan. The lifestyle and diet of the Japanese population have changed significantly since the end of World War II (Fig 2.2). In general, the Japanese have become more sedentary and they consume more fat than in the past. Among Japanese men, these changes have been associated with a steadily increasing body mass index (BMI), a well-known risk factor for the development of insulin resistance, impaired glucose tolerance, and diabetes. Genetic characteristics common to many Japanese may also contribute to their higher prevalence of diabetes.

### **2.2.4 Diabetes Trends in USA**

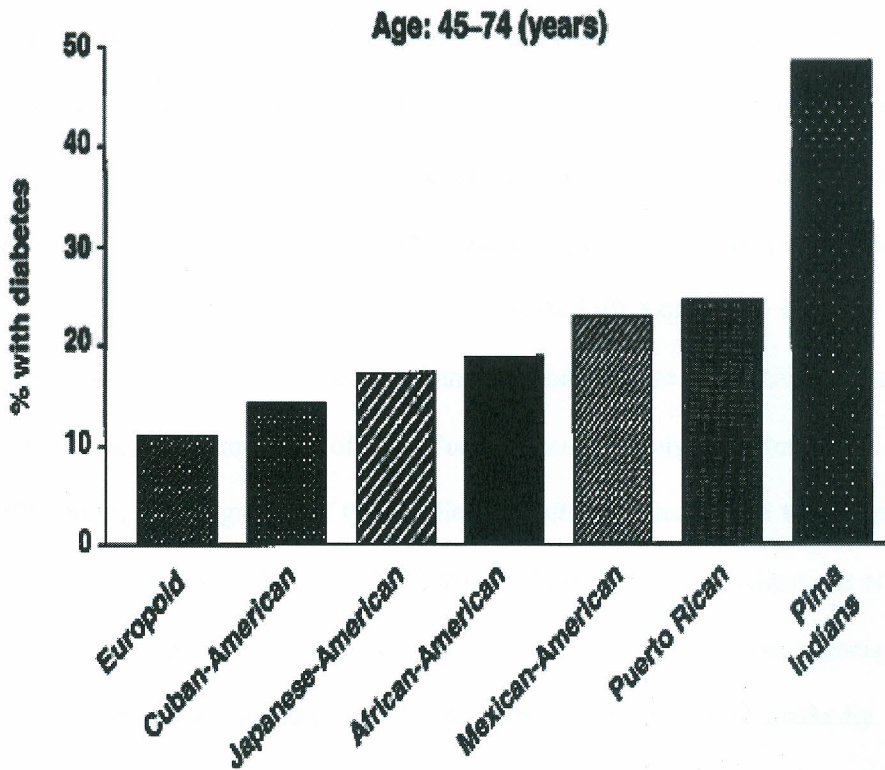
Type 2 Diabetes is a serious and costly health problem affecting more than 16 Million people in the United States (US). The rates of IGT are high thus indicative of a growing number of T2D patients. The increasing rates of obesity and trends towards sedentary lifestyles exacerbate the situation.



Source: Adopted from Kawamori 2002

**Figure 2.2: Changes in lifestyle/environmental factors thought to play roles in the prevalence of Diabetes in Japan**

The prevalence increase by age; varies by race, ethnicity and gender. In 1996, the total health costs of USD 120 Million were attributed to T2D. It is estimated that more than 16 million have Diabetes, 10 million of them T2D while 5 million of these are not aware of their disease.



Source: Adopted from Skyler 2002

**Figure 2.3: Prevalence of diagnosed diabetes by ethnicity, 1958–1993 (NHANES III)**

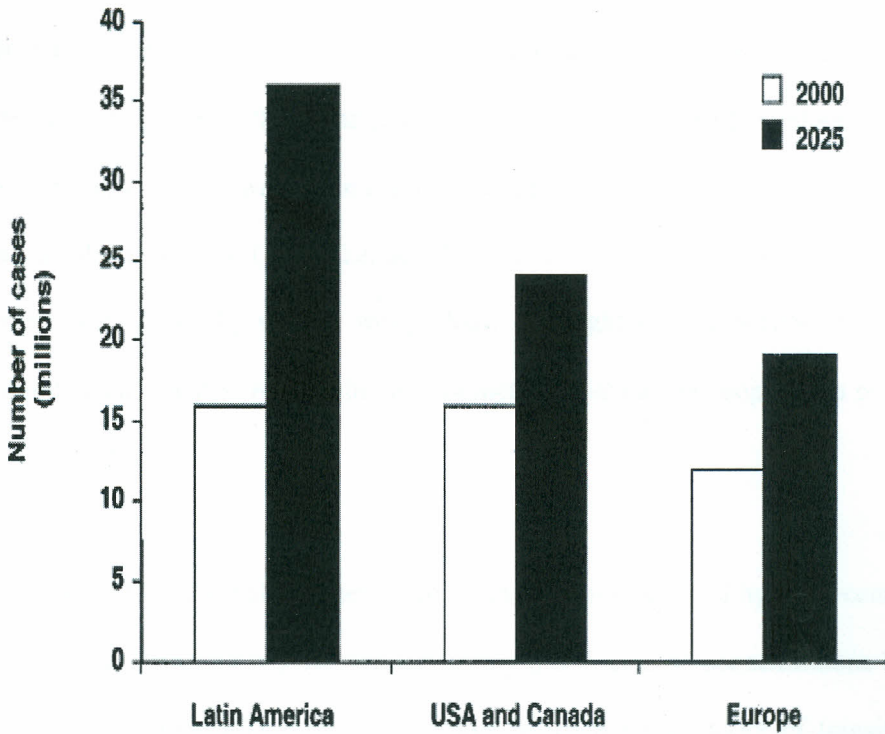
There are gender, racial, and ethnic variations in the prevalence of diagnosed diabetes in the US. The incidence of diagnosed diabetes continues to increase with age in non-Hispanic white, non-Hispanic black, and Mexican American men and women, as shown in the Third National Health and Nutrition Examination Survey, 1988–1994 (NHANES III). Considerable variations in the prevalence of diagnosed diabetes exist among ethnic groups (Figure 2). Pima Indians have the highest rate of diagnosed diabetes (48%), with high rates also seen in Mexican Americans (24%) and Puerto Ricans (26%)

### **2.2.5 Diabetes trends in Latin America**

The frequency of diabetes in Latin America is expected to increase by 38% over the next 10 years, compared with an estimated 14% increase in the total population. The total number of cases of diabetes is expected to more than double and to exceed the number of cases in the US, Canada, and Europe by 2025 (Figure 2.4). Factors underlying this increase include aging and increased life expectancy of the population, increased urbanization, and lifestyle changes among Native American populations. In many places, only a minority of individuals currently receives treatment for diabetes. Furthermore, the diagnosis of type 2 diabetes often occurs late in the course of the disease, with the result that 10–40% of patients have chronic complications at the time of diagnosis. Hospital costs account for most direct expenditures associated with treatment, and mortality associated with diabetes has increased markedly in some areas over the past 2 decades.

### **2.3 Relationship between Obesity and Type 2 Diabetes**

The strongest and most consistent risk factors for diabetes and insulin resistance among different populations are obesity and weight gain; for each increase in BMI, the risk of diabetes increases by 12%. The distribution of fat around the trunk region or central obesity is also a strong risk factor for diabetes (Jamison *et al.*, 2006).



**Figure 2.4: Estimated number of cases of diabetes in Latin America, the USA and Canada, and Europe in 2000 and 2025**

The prevalence of T2D is rising because of increasing prevalence of its key risk factors, which are obesity (BMI>30), a sedentary lifestyle, and an unhealthy diet of processed foods. Many of T2D patients are obese and mostly with visceral (intra-abdominal) obesity known to cause IR. Studies suggest that waist circumference greater than 35 inches in women and 40 inches in men signify increased risk for heart disease and diabetes (Galal, 2002). One of the determinants of central obesity is diet high in saturated fats that predispose to IR and high carbohydrate diets that exacerbate metabolic features of IR syndrome especially hypertriglyceridaemia.

Type 2 Diabetes is three times more likely to develop in an obese person than in a non-obese person; furthermore, the person with T2D often has central obesity. Central

body fat cells appear to larger and more insulin resistant than lower body fat cells. Diabetes seems to be influenced by gain in weight as well as elevated body weight. A weight gain of above 10 pounds since age 18 doubles the risk of developing T2D even in women of average weight. In contrast, weight loss is effective in improving glucose and insulin resistance (Schlenker and Long 2007). Risks associated with obesity are generally reversed by modest weight loss. A weight loss of 5-10% of initial body weight is sufficient to reduce the development of diabetes in people with pre-diabetes by up to 58%.

Diagnosis of T2D is solely determined by the demonstration of hyperglycemia (Table 2.2). IFG is characterized by elevated fasting blood glucose concentrations but not in the diabetic range. IGT represents a stage in the natural history of transition from normal glucose tolerance to frank diabetes. IGT is not a clinical entity in itself but defines a risk category for progression to diabetes (WHO, 1999).

The prevalence of these complications increase with duration of the disease and the risk is greater with poor glycemic control. Management of DM that includes use of insulin and dietary control can help alleviate symptoms and prevent the acute metabolic complications of diabetes.

**Table 2.2: Diagnostic blood glucose concentrations (mmol/L)**

Diagnosis	Sample	Venous plasma	Venous blood	Capillary blood
Normal	fasting	< 6.1	< 5.6	< 5.6
IFG	fasting	> 6.1 & <7.0	> 5.6 & < 6.1	> 5.6 < 6.1
	2 h post glucose	< 7.8	< 6.7	< 7.8
IGT	fasting	< 7.0	< 6.1	< 6.1
	2 h post glucose	> 7.8 & < 11.1	> 6.7 & <10.0	> 7.8 & <11.1
DM	fasting	> 7.0	> 6.1	> 6.1
	2 h post glucose	> 11.1	> 10.0	> 11.1

Source: Diagnostic values for oral glucose tolerance test (WHO, 1999)

#### 2.4 Physical Activity in Diabetes Management

Physical activity, including appropriate endurance and resistance training, is a major therapeutic modality for T2D (ACSM 2006). The main reasons that make exercise such a useful form of treatment of diabetes is the fact that it reduces the need for insulin by increasing body sensitivity to insulin, facilitates lowering of blood glucose levels (Howley and Franks, 1992) and weight control (Chen *et al.*, 2004). Intervention studies about the body's sensitivity to insulin have shown that physical activity plays a major role in glucose tolerance and insulin sensitivity (Clark, 1997). The point to note is that during and after exercise the muscles have an increased sensitivity to the available insulin, thus blood glucose is taken up by muscles faster than usual (Howley and Franks, 1992). Conditions of low-intensity exercise (50% VO<sub>2</sub> max) are as effective as high-intensity exercise (75% VO<sub>2</sub> max) in enhancing insulin sensitivity in people with NIDDM (Adrienne 2001). Physical activity therefore helps the body to depend on reduced levels of insulin thus a diabetic can eliminate or reduce the need for medication in the management program. However the physical activity patterns over climatic seasons has not been established among free living tropical populations.

The American College of Sports Medicine noted that moderate physical activity could be an effective way of lowering blood glucose levels since it stimulates muscles into taking up glucose almost 20 times more than normal rates. On the other hand it would seem that intense physical activity increases blood glucose because the body perceives exercise as a stress, thus releasing stress hormones that promote the release of blood glucose (ACSM, 2006). Boulé *et al* (2001) studied the effects of structured exercise intervention in Type 2 diabetes. This study found that moderate intensity physical activity can reduce HbA<sub>1C</sub> by 0.6% among Type 2 diabetics.

According to the UK Prospective Diabetes study the 0.6% decrease was sufficient to reduce the risks of micro-vascular complications by 22% (Stratton *et al* 2000). Conclusions were that structured exercise programs have a statistical and clinical significant beneficial effect on glycemic control. However, a similar degree of glucose lowering (0.6% of HbA<sub>1C</sub>) can be achieved by adding a single oral hypoglycaemia medication. Nevertheless large cohort studies have found that higher levels of habitual aerobic fitness and/or physical activity are coupled with other benefits other than just glucose lowering. The magnitude of decrease in blood glucose is related to the duration of the physical activity and is further modified to pre-exercise glucose and the novelty of the activity (ACSM, 2006).

Unlike the Type 1 diabetics who mainly struggle to maintain control of blood glucose levels, the Type 2 diabetics have exercise as a primary recommendation to deal with obesity that is usually present (Steyn *et al.*, 2004). Obesity is associated with insulin resistance (Andreoli *et al.*, 1997). Exercises help in utilising excess body fat, decreases body weight thus improving insulin sensitivity. A university based research

on weight loss and weight management using exercise, diet and behavioural modification concluded that exercise induced weight loss result in greater improvement in insulin sensitivity than diet induced weight loss alone. However, a combination of exercise, dietary caloric restriction and behavioural modification leads to weight loss of 9 to 13.6kg after 20weeks and ~ 60% of this weight loss is maintained over 1 year of follow up (ADA, 2004).

Walking, independently of participation in vigorous physical activity, has been reported to be associated with lower risk of Type II diabetes (Adrienne, 2001). Walking is especially suitable for older people and the functional gains it elicits will likely improve quality of life while being acceptable and carries low risk to injury. In various cross-sectional studies, groups of subjects with T2D were found to be less active and reported less physical activity over their lifetime than individuals without diabetes. In addition the blood glucose levels after an OGTT showed significantly higher values in less active individuals compared to the more active ones (Albright, *et al.*, 2000).

## **2.5 Dietary Practices and Physical Inactivity Variations**

Physical inactivity is a waste of human potential for health and wellbeing and its high prevalence is a cause of concern (Hardman, 2001). It's a potential contributor to positive living not only averting disease but also increased enjoyment of life and improved ability to withstand challenges (Hardman, 2001). Americans and urbanites live in an environment rendered unhealthful by their easy access to energy-dense foods and an increasing number of devices that reduce their energy expenditure. Environment affects policies of companies, government agencies and other

organizations whose decisions influence many people and it may change the unhealthful habits and thereby change obesity at a population level. In addition, the fact that the current environment is not conducive for healthful eating and activity may explain the poor maintenance seen in many physical activity and nutrition programs (Wing *et al.*, 2001). Obesity and physical inactivity are major modifiable behavioural risk factors for the T2D, although other factors such as low birth weight, breastfeeding and the intrauterine environments also play an important role. Furthermore, randomized controlled clinical studies have shown that weight loss and increased physical activity reduce the incidence of T2D in high risk individuals including those with IGT (Schulz *et al.*, 2006). Most Obese, Type 2 Diabetic individuals exhibit decreases in blood sugar after mild to moderate exercise. The magnitude of the decrease is related to the duration and intensity of physical activity and further modified by pre-exercise glucose level (Albright *et al.*, 2000).

Changes in the body composition are affected by climatic changes due to variations in the diet intake and physical activities. Motoi *et al* (2004) observed increases in plasma glucose and HbA<sub>1C</sub> levels in patients with T2D during winter in Japan. They attributed this to the decreased physical activity and increased food intake during winter, while in summer the body fat and HbA<sub>1C</sub> decreased. They explained these variations in HbA<sub>1C</sub> to be due to insulin resistance during winter. They concluded that seasonal changes in body fat rather than body weight might contribute to seasonal variation in plasma glucose control in patients with T2D. However, fluctuations in HbA<sub>1c</sub> by due to climatic change have not been reported in large populations of people and whether these fluctuations differ by individual characteristics such as sex, age, race or diabetes status is not known (Tseng *et al.*, 2005). Mathews *et al* (2001) found that physical

activity energy expenditure increased by 1.4 METS hrs/day (121Kcal/day) in men and 1.0 METS hrs/day (70Kcal/day) in women, while combined moderate intensity household and leisure time activity increased by more than 250Kcal/day during summer in comparison to winter. Mathews *et al* (2001) observed complex patterns of seasonal change that varied in amplitude and phase by type and intensity of activity by subject characteristics. Thus it is important to use such information for health promotion efforts designed to increase populations' levels of physical activity over the climatic seasons. The current study therefore proposes to determine variations in physical activity levels among the tropical communities in light of the fact of increasing prevalence of T2D in tropical African countries.

Christensen *et al.*, (2009) compared physical activity patterns of three rural communities and a mixed urban population in Kenya with respect to changes due to urbanization. They found that urbanization affected the physical activities engaged by men more than women especially with significance ( $p=0.002$ ) specifically in the house work and leisure time physical activity. They however did not pursue the changes in physical activities over the seasons. They further found that the sleeping heart rate (SHR) for females was lower than that for men during the season of the study. This, they attributed to the less mental stress (measured by lower heart rate) among the women and not necessarily the physical work intensity during the season.

This study pursued the variations in the physical activity levels among both sexes and communities and try to further explain the relation to T2D. Though it cannot be directly extrapolated to a tropical community, Mathews *et al* (2001) showed that extreme environmental factors modify physical activity behavior. Hajame *et al* (2001)

observed that seasonal variations in HbA<sub>1c</sub> levels were caused by an increase in dietary calorie intake and decrease in physical activity during cold seasons. It is therefore reasonable for diabetologists and dieticians to modify prescriptions for diabetic patients whose opportunities for physical exercise and dietary intake are altered by socio-cultural practices. Phasqui *et al.*, (2003) showed that there are significant variations in the sleeping metabolic rate among healthy individuals over autumn, summer, spring and winter, indicating that ambient temperature has a long term effect on human metabolism and thus direct effect on metabolic disorders like T2D. In another article, Plasqui and Westerterp (2004) found that there were no significant differences in total energy expenditure between winter and summer among Dutch young adults.

However the physical activity level was higher in summer than in winter and they reported a strong linear relation ( $R^2=0.48$ ) between physical activity level and physical fitness. Singh *et al.*, 1989 described the diet intake and energy expenditure among Gambian women. They found that in free living subjects energetic stress was high during the agricultural workload period coinciding with the hungry season, leading to moderate to severe energy balance especially among the active non affluent women (Singh *et al.*, 1989).

## **2.6 Diabetes Prevalence among the Blood Types**

Diabetes prevalence reveals increased mortality rate in alkaline blood types (blood types A and O) (Adamo, 2001). The A- protein is alkaline as it is made up of more of the alkaline amino acids. The B- protein is more acidic with more of the acidic amino acids. When the A and B proteins are present together as is in blood type AB, the PH

of the blood is in a balance state or approximately PH of 7.0, also indicative of the nutrient-mineral balance. Individuals with blood types A and O have an inclination to over-excrete the acidic minerals and/or overload alkaline minerals while those with blood type B are inclined to overload some acidic minerals and /or over-excrete alkaline minerals, all cases due to copper deficiency (Mohammed *et al.*, 2007). The current study therefore aimed to determine the prevalence of T2D among the various blood types to try elucidate which type are more susceptible and compare variations between and within the groups.

### **2.7 Fat Intake Relation to Type 2 Diabetes**

Type II Diabetes Mellitus (T2D), can be aptly named a “bad food disease” in combination with other lifestyle factors and a susceptible genotype (Amos *et al.*, 1997). Our bodies need fat, however, it must be the right kind of fat. Both the amount and quality of dietary fat may modify glucose tolerance and insulin sensitivity. High saturated fat content in the diet may result in deterioration of glucose tolerance by mechanisms like decreased binding of insulin to its receptors and consequently impaired glucose transport.

Higher proportions of saturated fatty acids intake have also been associated with higher fasting insulin concentrations (Marshall *et al.*, 1997) and a lower insulin sensitivity index and consequently, higher risk of type 2 diabetes (Lovejoy and Digirolamo 1992). On the other hand, there are several studies, which show no association between diabetes risk and total fat intake (Feskens *et al.*, 1991; Salmeron *et al.*, 2001; colditz *et al.*, 1992). Omega-3-fatty acids are a form of polyunsaturated fats, mainly eicosapentaenoic acid (EPA C20,5) and docosahexaenoic acid (DHA

C22,6), both found primarily in fish. They are increasingly recognized as important to human health but it is not yet clear how beneficial they can be in averting the risk of T2DM (Kris-Etherton *et al.*, 2002). It was therefore important for this study to be able to establish the risk of T2DM occasioned by dietary saturated fat intake vis-à-vis polyunsaturated fats like n-3FA. Clinically, early detection of diabetes provides an opportunity to reduce the progression of microvascular or macrovascular diseases caused by asymptomatic hyperglycemia. It was therefore important to establish the prevalence of IGT in the rural areas among populations of varying dietary practices.

## 2.8 Variations in Lipid Profile

Dyslipidemia is one of the determining factors for metabolic syndrome. The serum lipid levels are correlated to the dietary fat intake. Schutte *et al.*, 2004 showed that an urban male population has a higher fat content with their percentage body fat being significantly higher than their rural counterparts in South Africa. However, the TC, HDL-C, LDL and TG did not differ significantly among the rural and urban males. They concluded that in males adopting westernized lifestyle there is a questionable effect of lipid profile on their vasculature. The dietary LDL and HDL cholesterol levels have opposite effects in relation to risk of disease (Mensink and Katan, 1992). The mean serum total cholesterol concentration of Fulani men and women was found to be on the lower side of the reference range for African Americans. The mean HDL concentration was found to be higher in the Fulani females compared to the male counterparts (Glew *et al.*, 2001).

## 2.9 Conclusion

The need for physical activity control in the management of T2D cannot be overstated. It is also evident that the negative energy balance occurs in some communities, thus the need to determine how this affects the prevalence T2D and its risk factors.

## CHAPTER THREE

### METHODOLOGY

#### 3.0 Introduction

This chapter presents the research design, target population and sampling procedures and techniques for this study. It provides an overview of the research instruments required and concludes by elaborating data handling procedures.

#### 3.1 Research design

A cross-sectional study was conducted in Nyangoma Division, Bondo district and in Soin Division, Kericho District of the Lake Victoria Basin. Both districts are in the same geographical and climatic belt but the communities differ by their socio-cultural and dietary practices. The locations were randomly sampled while the districts were purposively sampled to represent the area of same environmental conditions.

#### 3.2 Variables

The dependent variables mainly focused in this study are, Impaired Glucose Tolerance, Fasting Blood Glucose, Diet intake, percent body fat, Body Mass Index and physical activity level. The independent variables include the blood types, sex, ethnicity, age categories and glucose tolerance categories.

#### 3.3 Location of the Study

The study was conducted in Nango location of Nyangoma Division, Bondo District and Kipsitet location of Soin Division, Kericho district of the Lake Victoria Basin of Kenya. Both regions have the same climatic patterns and temperature levels. They however are occupied by communities from two different agricultural and cultural

backgrounds. The Luo mainly practice fishing and subsistence farming while the Kipsigis are mainly agro-pastoralists.

### **3.4 Target population**

Adults of both sexes from the two communities meeting the following criteria were eligible for the study.

#### **3.4.1 Inclusion criteria**

- Age between 18 and 60 years
- Lived in the area for at least five years prior to the beginning of study.

#### **3.4.2 Exclusion criteria**

- Non consenting individuals
- Pregnancy and/or chronic ailments other than diabetes.

### **3.5 Sampling Techniques and Sample Size**

#### **3.5.1 Sample size determination**

The sample size calculations are based on the formula for adequate power to detect differences in proportions. To compare the means of variables determined between the two independent populations, the sample was calculated using the G-power statistical power determination programme created by Faul *et al.*, (2007). The random samples of 150 individuals from each of the communities of the Lake Victoria basin were used as study subjects. Using a medium effect rate of 0.25,  $\alpha = 0.05$  and a non-sphericity correlation of 0.5 (Faul *et al.*, 2007), this study has considerably more power to detect the changes within the variables and differences between the two communities. Similarly, the study has considerably more power to detect significance differences

(95% confidence level) in other continuous variables, such as physical activity, dietary intake, and nutritional status within and between the communities. The randomly selected individuals were issued with identification numbers and each given a card indicating the date of appointment at the respective clinic for testing. They were advised to fast at least for 8 hours on the night before the study and not to take anything except plain water in the morning of the test.

### **3.5.2 Sampling procedure**

In the study area within Lake Victoria basin, all administrative divisions, locations, sub-locations, villages and homesteads was listed from the demographic data available from the latest surveys by the Kenya National Bureau of Statistics (KNBS). SPSS was then be used to generate a random list that gave the homesteads from which the study population was drawn. Spin the pen technique was also used to select alternative households where the pre-selected household was found empty. From each household, all adults between 18-60 years were listed. The sampling frame was the list of adults meeting the inclusion criteria in each homestead. Assuming a refusal rate of 10% and loss through natural attrition at 10%, a random sample of 180 individuals were selected from each the communities.

### **3.6 Research instruments**

A structured questionnaire was used to collect data (Appendix 2-5). The sections of the questionnaire are hereby discussed.

### **3.6.1 Socio-Demographic Data**

Interviews were carried out to provide general demographic and socio-economic information of the rural communities (Appendix 2). The data were used to categorize the individuals to various socio-economic statuses. These categories were used to compare the physical activity levels and dietary patterns as well as prevalence of T2D and its risk factors.

### **3.6.2 General Health Assessment**

A medical history, including signs and symptoms of diabetes, was taken and data on smoking habits and drug intake was obtained from each subject (Appendix 3). A general clinical and physical examination were performed, including blood pressure (mmHg), and temperature taken. The blood pressure was taken twice on the left arm with the subject seated and after they rested for five minutes using a manual sphygmomanometer (Model: AH3028; Manufacturer Xianxiang Golden Elephant Ltd, China). The blood flow through the artery was monitored using a stethoscope (Model: 3200; Littmann Electronic Ltd, USA) as the cuff pressure is allowed to slowly decline.

### **3.6.3 Nutritional Assessment**

Dietary intake was assessed using a combination of food frequency questionnaire (Appendix 4) and 24-hour recall record form (Appendix 5), with emphasis on establishing intake of foods and food patterns. Secondary data from a nutritional study done in some selected communities of the Lake Victoria region complemented this study in determining food intake patterns. Intake of specific nutrients was estimated using local food composition tables as well as the Nutri-survey computer software. The diet intake was calculated and compared within and between groups.

### 3.6.4 Body Composition Determinations

Anthropometric measurements were taken using international standards for anthropometric assessment. Body composition was determined based on measurements of height, weight, body fat, mid-upper arm circumference, hip and waist circumference, and calf circumference measurements (Appendix 9). Measurements of height, weight, and waist and hip girth were taken with light clothes without shoes. The weighing tools were calibrated daily by known standard weight. For height, the subject stood in erect posture vertically touching the occiput, back, hip, and heels on the wall while gazing horizontally in front and keeping the tragus and lateral orbital margin in the same horizontal plane. Waist girth was measured by placing a plastic tape horizontally midway between 12th rib and iliac crest on the mid-axillary line. Similarly, hip was measured by taking the extreme end posteriorly and the symphysis pubis anteriorly.

Weight was measured to the nearest 100 grams (0.1kg) using a Soehnle bathroom scale, after calibrating it to zero, and after removal of shoes and excess clothing and weight and height were taken twice. In order to ensure quality data, the weighing scale was calibrated before measuring of weight began everyday and every now and then during the measuring exercise. Waist circumference was measured using a non-stretchable tape halfway between the lower border of ribs and the iliac crest on a horizontal plane, while ensuring that the tape was level around the body and parallel to the floor. The tape was tightened around the body without depressing the skin. Two measurements to the nearest 0.1cm were taken and the mean recorded (Marfell-Jones *et al.*, 2006).

Percentage of body fat was measured using a Soehnle scale which estimates the body fat percentage by the bioelectrical impedance (BI) Analysis system. Body Mass Index was calculated as  $\text{Weight (Kg)} / \text{Height (M)}^2$  and recorded for each individual.

### **3.6.5 Physical Activity Assessment**

IPAQ short form is an instrument designed primarily for population surveillance of physical activity among adults. It has been developed and tested for use in adults (age range of 15-69 years). Daily physical activity patterns were assessed using the Cora *et al.*, (2003) validated standard International Physical Activity Questionnaire (last 7 days or usual week) (Appendix 6). The physical activity patterns and physical activity levels were derived and estimated using the hours of activity and Metabolic Equivalence (MET) values.

## **3.7 Laboratory Procedures**

### **3.7.1 Diabetes Risk Factors**

Diagnosis of impaired glucose tolerance, IFG and diabetes was done based using the fasting blood glucose (FBG) and 2 hour post-load blood glucose level. Measurement of fasting glucose was carried out before the oral interviews. The interviews and the blood tests were carried out at local clinics of the participants.

### **3.7.2 Oral Glucose Tolerance test protocol**

For diagnostic purposes, a two-hour oral glucose tolerance test (OGTT) was administered to persons at risk for diabetes but exempted to those with established diabetes. All subjects with an FBG  $< 6.1$  mmol/L were given a 75-gram carbohydrate load in 300ml solution after their fasting blood samples were drawn, and another

blood sample was drawn two hours later to assess post-load glucose levels. World Health Organization (2003) criteria was applied to classify individuals on the basis of their OGTT as either normoglycemic (fasting and two-hour plasma glucose  $\leq 7.8$  mmol/L); having impaired glucose tolerance (IGT) [two-hour plasma glucose 7.8-11.0 mmol/L]; or having diabetes (two-hour plasma glucose  $>11.1$  mmol/L) (Metzger *et al.*, 2010).

### 3.7.3 Blood group and Rhesus factor determination

A blood type (also called a blood group) is a classification of blood based on the presence or absence of inherited antigens on the surface red blood cells. The antigens may be proteins, carbohydrates glycol protein or glycol lipids depending on the blood group system and some of the antigens are also present on the surface of other types of cells of various tissues. Several of these erythrocyte surface antigens from one allele collectively form a blood group system. Blood grouping (ABO and Rh) was done by the antigen-antibody agglutination test. Plasmatic ABO monoclonal reagents are *in vitro* culture supernatants of hybridized immunoglobulin secreting mouse cell-line. For determination of Rh factor, plasmatic anti D (1.0 g) Lo-Du and LO-Du2 monoclonal reagents, prepared from different antibody producing human B-lymphocyte cell lines, were used. The tiles were labeled as per the subject numbers. A drop of the antibodies anti-B, anti- A and anti-D were placed into three different wells of the tiles. The finger were sterilized with 78% alcohol, left to dry and then pricked with a blood lancet. A drop of blood was placed in the three wells with the three antibodies. The mixture was stirred thoroughly with an applicator stick to mix blood with the antibodies. Observations were made for agglutination or not and the blood group were recorded.

### 3.7.4 Quantitative determination of Lipid Profiles

The levels of the three lipids: triglycerides, cholesterol and high density lipoproteins (HDL) were determined by enzymatic colorimetric methods using the standard Human Diagnostics Worldwide kits ([www.human.de](http://www.human.de)) according to the manufacture instructions as highlighted below for each parameter. Two spectrophotometers, Genesys 10 uv scanning (Thermo Scientific) and Jenway 630 were used to double read the optical absorbance at 500nm wavelength through an optical path of 1 cm at room temperature. The heparinized,  $-30^{\circ}\text{C}$  previously frozen serum samples were first thawed and brought to room temperature just before the enzymatic reactions were carried out. All the spectrophotometer readings were made within 1h of the various reactions against the specific reagent blanks.

#### 3.7.4.1 Triglycerides Assay

Triglycerides were determined after enzymatic hydrolysis with lipases using Quinoneine formed from hydrogen peroxide, 4-aminoantipyrine and 4 chlorophenol under catalytic influence of peroxidase as indicator according to the methods of Schettler *et al.*, 1975, Jacobs *et al.*, 1960 and Trinder, 1969. 10  $\mu\text{L}$  of samples were pipetted into cuvettes and 1000  $\mu\text{L}$  of the triglycerides liquicolor<sup>mono</sup> were added into each cuvette, vortex mixed and incubated for 10 min. at room temperature and the absorbance of the samples and the standard measured against the reagent blank. 10  $\mu\text{L}$  of the triglycerides standard was reacted with the reagent. One triglyceride reagent blank per series was used.

### 3.7.4.2 Cholesterol Assay

Using the methods Schettler *et al.*, 1975; Trinder, 1969; Richmond (1973); and Roschlau, 1974; 10  $\mu\text{L}$  of samples were pipetted into separate cuvettes and 1000  $\mu\text{L}$  of the Cholesterol liquicolor reagent was added into each cuvette. These were then mixed and incubated for 10 minutes at room temperature. 10  $\mu\text{L}$  of the cholesterol standard enclosed in the kit was also dispensed into one cuvette and treated as the samples.

### 3.7.4.3 HDL Assay

This was done according to the protocol of Gordon *et al.*, 1977 and Friedewald *et al.*, 1972 in which the chylomicrons, Very Low Density Lipoproteins (VLDL), and Low Density Lipoproteins (LDL) were precipitated by addition of phosphotungstic acid and magnesium chloride. After centrifugation, the supernatant containing the High Density Lipoprotein (HDL) fraction was assayed for HDL cholesterol with cholesterol liquicolor test kit. A sample of 200  $\mu\text{L}$  were pipetted into eppendorf tubes, 500  $\mu\text{L}$  of precipitant for semi-micro assay was added, vortex mixed and incubated for 10 min at room temperature. The reactants were then centrifuged at 10000g for 2 min. 100  $\mu\text{L}$  of the resultant clear supernatant was pipetted and the cholesterol determined within 1 hour after the reaction. A sample of 100  $\mu\text{L}$  of distilled water was mixed with 1000  $\mu\text{L}$  of cholesterol liquicolor reagent to make the blank and 100  $\mu\text{L}$  of HDL standard was added onto 1000  $\mu\text{L}$  of the reagent and was read as the standard. The colorimetric reaction mixtures were incubated after vortex mixing in the cuvettes for 10 minutes.

## 3.7 Pretesting of Study instruments

A pre-test of the study instruments comprised of 20 subjects to test and validate the tools and techniques to be used in the main study. The subjects for the pretest were recruited randomly from Kenyatta University, Kahawa Wendani, Ruiru and Githurai

Market. Although the pretest site was not the same as the study population, the tools used for data collection were validated and translated to suit the study population.

### **3.8 Validity and Reliability**

Validity of the research instruments and variables was measured using the Pearson correlation (Hopkins, 2000). Reliability of the observations in each of the variables for the repeated tests measurements were tested using interclass coefficients given by Hopkins (2000). This was done using the 20 questionnaires from the pilot study, and a correlation in validity and reliability  $\geq 0.5$  was found to be specific.

### **3.9 Data Management**

#### **3.9.1 Data Collection Techniques**

Questionnaires were administered through oral interviews by the investigators with the assistance of trained field workers. The laboratory analysis of the samples was done in the field on daily basis. Reviewing and coding of the questionnaires was done daily in the field before being filed ready for data entry.

#### **3.9.2 Data Storage and Analysis**

Data were entered, analyzed and stored using SPSS version 11.5. Normality of continuous variables was assessed using normal plots. Summary statistics were computed for continuous (mean  $\pm$  standard deviation) and categorical variables (number and percent). Community differences were tested by chi-squared test, Kruskal-Wallis test or analysis of variance (ANOVA), as appropriate. Analyses of relationships between physical activity, smoking status and fasting glucose were

undertaken by ANOVA, using pooled data blocked on community. Stepwise multiple regressions were used to determine the physiological, anthropometric and physical activity variables that were significant predictors of glucose intolerance among the two communities. Data from the 24 hr recall was entered into a modified version of Nutri-survey nutritional assessment program for quantitative calculations. The resulting data was transferred to SPSS for comparison and contrasting between the independent variables.

### **3.10 Ethical Considerations**

Oral and written information about the study in English, Kiswahili and/or the local language were given, and informed consent obtained from each subject prior to participation in the study. It was made clear that study participants can withdraw from the study at any time, and that confidentiality was maintained at all times during this study. Subjects were informed that blood collection could cause discomfort though there is no risk associated with any of the examinations. The study team worked closely with the Ministry of Public Health in the study sites and study participants found sick were referred to the local health facility for further examinations and treatment. Ethical approval was sought and granted by the National Ethical Review Board at the Kenya Medical Research Institute (Appendix 10).

## CHAPTER FOUR

### RESULTS AND DISCUSSION

#### 4.0 Introduction

This chapter presents the results and discussions of the current study. The study involved three hundred and four participants from the two districts (Bondo and Kericho) representing two communities namely the Luo and the Kipsigis respectively. It compares and contrasts the study findings with related concurring or conflicting findings from other populations done recently both in developed and developing countries. The chapter presents the study findings as per the objective and gives a summary sub-section (objective) of the study as follows: Demographics of the two populations (The Luo of Bondo district and the Kipsigis of Kericho District); Prevalence of T2D, impaired fasting glucose and impaired glucose tolerance between and within the two communities; Dietary patterns (quality and quantity) among the two communities; Physical activity patterns in relation to prevalence of T2D, IGT and IFG among the two populations; Body composition and anthropometric characteristics of the two communities as related to prevalence of T2D, IGT and IFG; Distribution of blood type within and between the two communities and its relation to prevalence of T2D, IGT and IFG; Lipid profile in relation to the prevalence of T2D, IGT and IFG and finally chapter summary and conclusions

#### 4.1 Demographic characteristics

The demographic characteristics of the population studied are presented in Table 4.1. The total number of subjects recruited was 304 (134 males and 170 females) to fulfill the 95% confidence level required for comparisons (Faul *et al.*, 2007). Of these 153 were from Kipsigis community while 151 were recruited from the Luo community

living in Kericho district and Bondo district respectively. The ratios of men to women and other background characteristics are presented in Table 4.1. The mean age of the subjects recruited to represent the population was 43 years (Range 19-88), while the mean age among the gender was 42 years and 47 years for the males and females respectively. There was no significant difference in the mean age of the two populations thus age was not a confounding factor in the differences in to the study populations. The populations live in one geographical region (Appendix 11) and thus climatic differences were not confounding factors in variations between the variables studied in the populations.

**Table 4.1: Background Characteristics by ethnic group**

	Luo (n = 151)	Kipsigis (n =153)	Total (n=304)	P-value
Male	65	69	134	
Female	86	84	170	
Age yrs (SD)	43 (15)	42 (16)	43 (16)	NS
Age range	19 – 82	20 – 88	19 – 88	
Age Categories				
19-30	(n =39)	(n =53)	(n =92)	
31-40	(n =32)	(n =30)	(n =62)	
41-50	(n =32)	(n =26)	(n =58)	
51-60	(n =29)	(n =23)	(n =52)	
>60	(n =19)	(n =21)	(n =40)	

NS – No Significant Differences

There were no significant differences in the overall mean age of the subjects in both areas. This means that during the comparisons between the two populations, the age will not be a confounding factor and therefore the results will be representative of the population. Generally it was observed that as the age advanced, there were lesser people willing to participate in the study. It was also observed that majority of the

individuals had blood Group O from both populations with more than 50% of the women being blood Group O. Therefore, this indicates that the populations were normally distributed and the results of the sample used can be used to estimate the population parameters.

## **4.2 Prevalence of Type 2 Diabetes, IGT and IFG within and between the two communities**

### **4.2.1 Prevalence of Type II Diabetes**

Type 2 Diabetes was measured using the fasting blood glucose of  $\geq 6.1$ mmol/l of venous blood. The overall prevalence of T2D in the rural areas represented by the sample (LVB) was found to be 2.3% of the population. The prevalence found to be 3.0% and 1.8% among the males and females respectively. The two hour glucose level showed that there were 1.3% of the Kipsigis people who had T2D (2 hour post load blood glucose  $> 11.1$ mmol/l) although they had normal fasting glucose. This was not observed among the Luo community. The prevalence of T2D, IFG and IGT are presented in Table 4.2 and Table 4.3 for the Luo and Kipsigis communities respectively. In both communities there was no significant differences in the mean fasting blood glucose among the males and females while the mean 2-hour post prandial glucose level differed significantly ( $p < 0.001$ ) among the gender.

The prevalence of diabetes was found to be lower than the global estimates by Hilary *et al.*, 1998. They estimated that the prevalence of diabetes in developing countries will rise to 5.4% in 2025 from 4% in 1995. These differences can be attributed to the fact that the current study was based on a purely rural population, while the estimates by Hilary *et al.*, 1998 were based on both rural and urban populations. Christensen *et*

*al.*, (2009) also demonstrated a high prevalence of T2D in the rural areas. They however cautioned on careful interpretation of these findings due to bias sampling caused by walk-in clients who were not randomly sampled. The current study avoided this scenario by randomly recruiting the participants and issuing them with appointment cards showing their full names, serial numbers and date of participation in the study. The sample therefore was non-biased and is representative of the two rural population of the Lake Victoria Basin.

**Table 4.2: Prevalence of T2D, IFG and IGT among the Luo Community**

Variable	Total	Male	Female	P-value
FBG	n 151	65	86	
Mean	4.7±1.2	4.6±1.1	4.8±1.3	NS
% Normal	94.7 (n=143)	98.5(n=64)	91.9(n=79)	
%IFG	2.6(n=4)	0	4.7(n=4)	
%Diabetic	2.6(n=4)	1.5(n=1)	3.5(n=3)	
2HR OGTT				
n	147	64	83	
Mean	5.5±1.2	5.2±1.3	5.8±1.0	p<0.001
% Normal	95.2(140)	96.9(n=62)	94.0(n=78)	
%IGT	4.8(7)	3.1(n=2)	6.0(n=5)	
%Diabetic	0	0	0	

NS – No Significant Differences

There was no significant difference between the fasting blood glucose between the males and the females among the Luo community. This concurs with the findings by Assah *et al.*, 2009 that the level of FBG did not differ among the gender in Cameroonian adults from both rural and urban areas. However, the current study found that there were significant differences (p<0.001) in the 2-Hour postprandial glucose level between the males and the females from the same population while

Assah *et al.*, 2009 found there were also no difference in the 2-Hour glucose level among the Cameroonian adults. This therefore implies that the females have a lower rate of sugar metabolism resulting in a higher residual glucose after 2 hours of the glucose challenge. The fasting blood glucose was not significantly different between the genders thus implying uniformity of the subjects' blood sugar level at the start of the glucose challenge.

**Table 4.3: Prevalence of T2D, IFG and IGT among the Kipsigis community**

KIPSIGIS COMMUNITY				
Variable	Total	Male	Female	P-value
FBG n	153	69	84	
Mean	4.8±0.7	4.8±1.0	4.8±0.3	NS
% Normal	95.4(n=146)	92.8(n=64)	97.6(n=82)	
%IFG	2.6(n=4)	2.9(n=2)	2.4(n=2)	
%Diabetic	2.0(n=3)	4.3(n=3)	0	
2HR OGTT				
n	152	68	84	
Mean	6.4±1.4	6.1±1.5	6.7±1.2	<0.001
% Normal	86.8(n=132)	94.1(n=64)	81.0(n=68)	
%IGT	11.8(n=18)	4.4(n=3)	17.9(n=15)	
%Diabetic	1.3(n=2)	1.5(n=1)	1.2(n=1)	

NS – No Significant Differences

The percentage diabetics is zero in the 2hr diagnostic procedure because there were no diabetics detected by the 2hr glucose challenge while the straight diabetics from the fasting blood glucose could not undergo the glucose challenge due to ethical reasons. This infers that people diagnosed with diabetes in the FBG could not be dosed with glucose challenge of the OGTT procedure.

#### 4.2.2 Prevalence of Impaired Fasting Glycemia

The impaired fasting Glycemia was measured using fasting blood glucose range of 5.6 – 6.1 mmol/l of venous blood. The overall prevalence of IFG was found to be 2.6% of the population in each of the two rural areas. The prevalence of IFG was found to be 1.5% and 3.5% among the males and females respectively. The prevalence was the same at 2.6% among the two rural communities however it varied among the males and females in each community. This was much lower compared to 12.4% crude prevalence of IFG found by Sayeed *et al.*, (2003) in a rural population in Bangladesh.

#### 4.2.3 Prevalence of Impaired Glucose Tolerance (IGT)

The IGT level was measured using the OGTT with a range of 7.8 -11.1mmol/l of the capillary blood glucose considered IGT. The overall prevalence of IGT in the rural areas was at 8.1% (CI: 5.0-11.2) of the total population. It was found to be 3.1% (CI: 0.2-6.0) and 11.3% (CI: 6.3-15.7) among the males and females respectively. It was also observed that the IGT prevalence among the Luo and the Kipsigis was 4.8% (CI: 1.4-8.2) and 11.8% (CI: 6.3-17.2) respectively. These results were found to be much lower than the adults in the United States whom 15.6% were diagnosed to be having IGT (Rao *et al.*, 2004). Christensen *et al.*, (2009) found a higher overall prevalence of IGT of 12.0% in selected Kenyan population groups. The combined prevalence of T2D, IFG and IGT is presented in Table 4.4.

**Table 4.4: Prevalence of T2D, IFG and IGT among the two communities**

Variable	COMBINED RURAL POPULATION			P-value
	Total	Male	Female	
FBG n	304	134	170	
Mean±SD	4.8±1.0	4.7±1.0	4.8±1.0	NS
% Normal	95.1(n=289)	95.5(n=128)	94.7(n=161)	
%IFG	2.6(n=8)	1.5(n=2)	3.5(n=6)	
%Diabetic	2.3(n=7)	3.0(n=4)	1.8(n=3)	
2HR OGTT				
n	298	130	168	
Mean±SD	5.9±1.3	5.6±1.2	6.2±1.2	<0.001
% Normal	91.6(n=273)	96.9(n=126)	87.5(n=144)	
%IGT	8.1(n=24)	3.1(n=4)	11.3(n=19)	
%Diabetic	0.3(n=1)	0	0.6(n=1)	

NS – No Significant Differences

#### 4.2.4 Prevalence of IGT, IFG and T2D by age categories

The prevalence of IGT, IFG and T2D among the age categories is presented in Table 4.5. In all the age categories, the females had higher percentage of IGT and IFG. This generally indicates that the females were more prone to glucose intolerance. This concurs with Garancini *et al* (1995), who found out that in Italy, the prevalence of previously undiagnosed diabetes prevalence was 2.5% and 3.4 % in males and females respectively. However, this differed with Dunstan *et al.*, (2002) who found that the prevalence of diabetes was higher in Australian males than in females at 8.0% and 6.8% respectively. It can therefore be alluded to that the prevalence among different populations differs by gender and that in Africans the females have a higher prevalence rates than the males unlike among the Caucasians.

**Table 4.5: Prevalence of T2D, IFG and IGT in Age categories by gender**

Age Category	Gender	% IGT	% IFG	% Diabetic
18 - 30 Years	Male	0	0	2.2
	Female	10.9	2.2	0
30 - 40 Years	Male	0	5.0	0
	Female	14.3	0	0
40 -50 Years	Male	9.5	0	4.8
	Female	8.1	2.7	5.4
51 – 60 Years	Male	0	4.3	4.3
	Female	20.7	0	3.4
Above 60 Years	Male	8.3	0	4.2
	Female	0	6.3	6.3
OVERALL	Male	3.0	1.5	3.0
	Female	10.0	1.8	2.4

These results also concur with a recent study in Kenya by Christensen *et al.*, (2009). They found that the prevalence of IGT was higher among females (12%) than in the males (11%) in a mixed population. Among the rural populations, Christensen *et al.*, (2009), reported high crude prevalence in diabetes (IGT + T2D) compared to the current study at 18.1% for females and 11.1% for males. However as mentioned earlier their results should be interpreted with caution due to the potential selection bias which may have over- or underestimated prevalence assessment.

The current study also indicates a general trend of increase in the number of diabetics by age, with subjects below 40 years hardly being diagnosed to have T2D. However the percentage of IGT was found to be high in all categories. The characteristics of the individuals with normal blood glucose, isolated IFG, isolated IGT and those with both IFG and IGT, is presented in Table 4.6.

**Table 4.6: Glucose metabolism by diabetic category**

	NFG/NGT	Isolated IFG	Isolated IGT	Both IFG/IGT	P-Value
Total N	267	5	21	3	
Ethnicity (L/K)	139/129	2/3	5/16	2/1	
Age	42.02±15.62	48.40±15.14	42.76±17.46	49.33±14.15	NS
Gender (M/F)	124/143	2/3	4/17	0/3	
BMI	23.27±3.93 <sup>a</sup>	22.92±4.72 <sup>a</sup>	25.02±7.21 <sup>ab</sup>	28.89±8.20 <sup>b</sup>	0.041
FPG	4.63±0.38 <sup>a</sup>	5.72±0.83 <sup>b</sup>	4.76±0.37 <sup>a</sup>	5.90±0.00 <sup>b</sup>	<0.001
PG <sub>30</sub>	6.85±1.37 <sup>a</sup>	8.38±1.09 <sup>ab</sup>	7.55±1.22 <sup>ab</sup>	8.60±3.01 <sup>b</sup>	0.002
PG <sub>120</sub>	5.69±1.02 <sup>a</sup>	6.22±1.14 <sup>a</sup>	8.39±0.53 <sup>b</sup>	8.07±0.23 <sup>b</sup>	<0.001

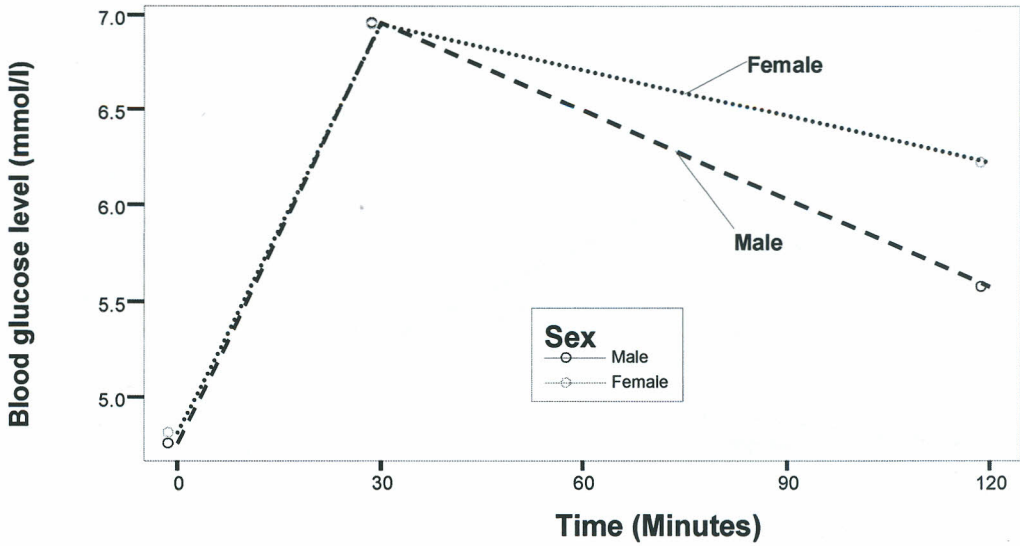
<sup>a</sup> Means on the same row with same letter are not significantly different  
NS – No Significant Differences

The results show that low BMI is a risk factor for isolated IFG while overweight and obesity are risk factors for isolated IGT and both having IFG and IGT. The glucose level monitoring after OGTT dosing was measured after 30 minutes and 120 minutes. It should be noted that from these results it was only females who were found to have both IFG in their fasting sugar level and IGT when exposed to the OGTT. Importantly, there were more female subjects who were diagnosed with isolated IGT. Therefore, females had a higher risk of developing glucose intolerance than males in the population studied.



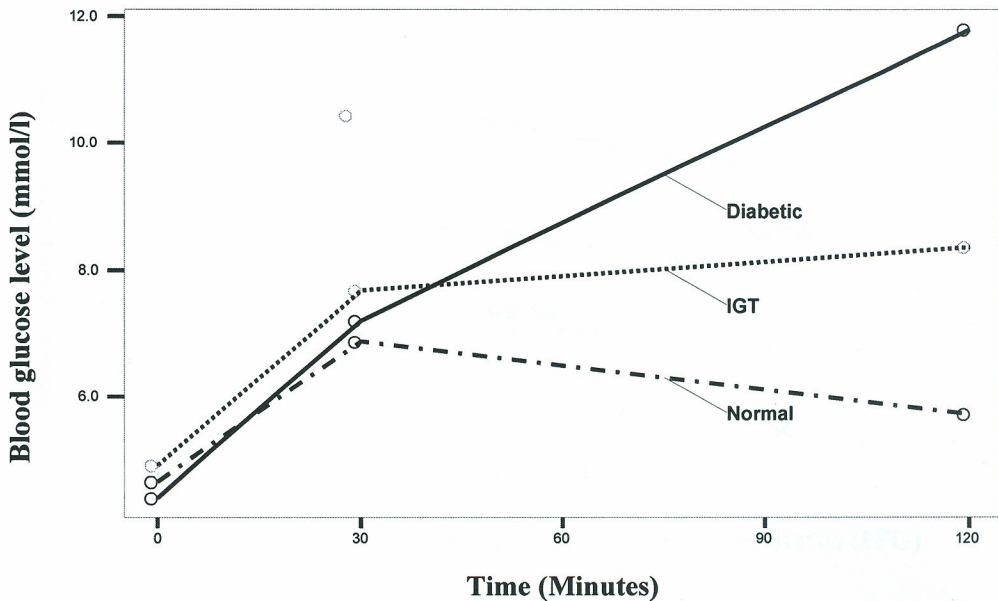
**Figure 4.1: Glucose Metabolism with Time**

The glucose intolerant and diabetic individuals have a higher mean FBG glucose and also a significantly higher residual 30-mins and 2-hr postprandial glucose level compared to the euglycemic individuals. The blood sugar kept increasing even after 2 hours of the glucose challenge, among the glucose intolerant group. This is an expected trend because these individuals do not utilize nor store sugar from the orally ingested glucose and indeed any food eaten. This causes accumulation of glucose in the blood which may overburden organs such as the kidney leading to the organ's failure. Analysis using the T-test showed that there were significantly higher residual glucose levels among the GI individuals than the GT people at fasting ( $p < 0.001$ ), 30 minutes ( $p = 0.008$ ) and after 2 hours ( $p < 0.001$ ).



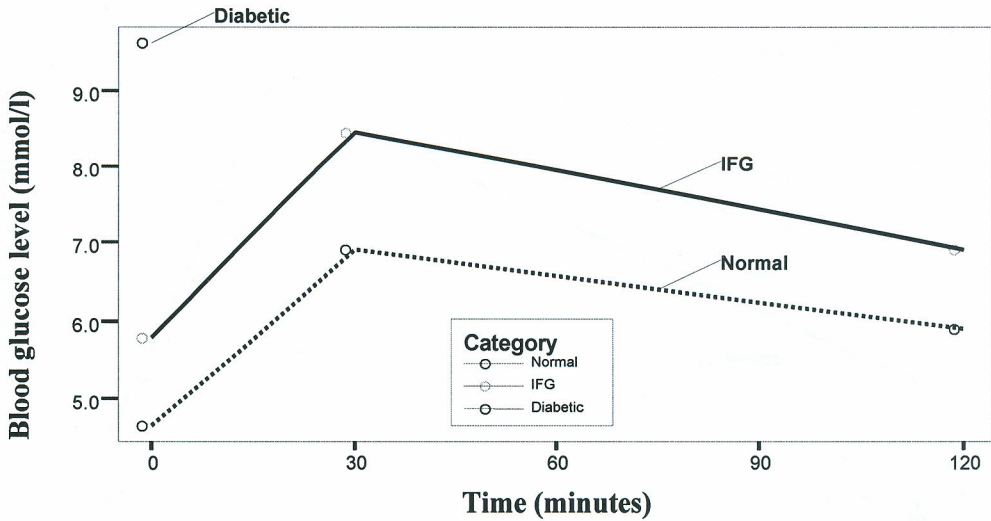
**Figure 4.2: Glucose Level with Time among Sex Categories**

There were no significant differences in the level of IFG and 30-mins postprandial glucose among the males and the females. However the females had a significantly higher 2 hour postprandial glucose level compared to the males. This indicates that the females from the two communities do not efficiently metabolize glucose as the men. Analysis using the T-test indicate that after 120 minutes after dosing, females from the two communities had a significantly higher ( $p < 0.001$ ) residual sugar than the males.



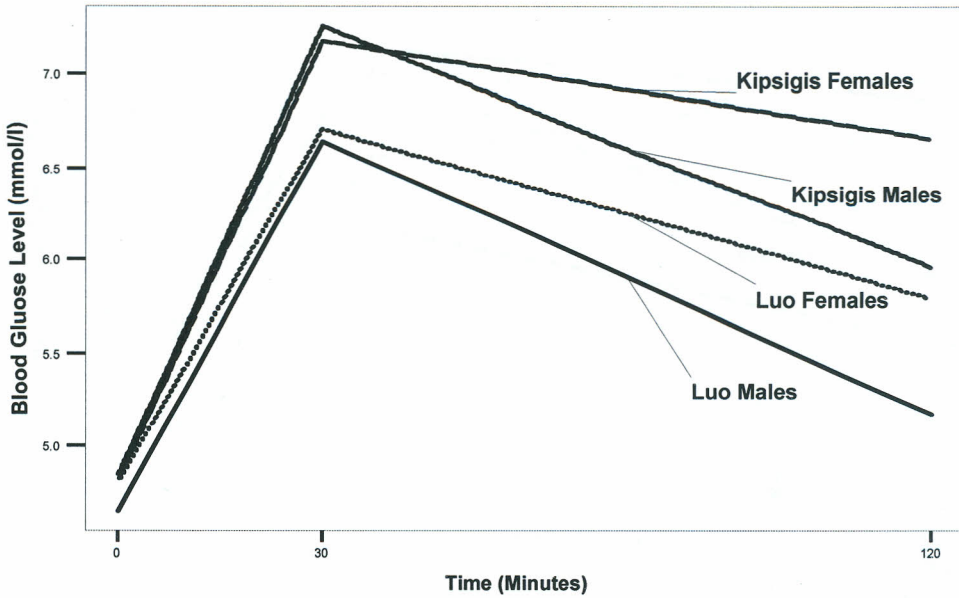
**Figure 4.4: Glucose Level with Time among Diabetes Status (IGT)**

Diabetic individuals were found to have the lowest mean FBG levels but their glucose levels kept increasing with the 2-hr postprandial glucose level being significantly different ( $p < 0.001$ ). These results clearly show that the diabetic individuals and those with IGT have a poor glucose metabolism of glucose as measured by the OGTT. It also gives the indication that IGT is a major risk factor for T2D because of the overall high residual blood plasma glucose levels. Analysis of variance showed that after 120 minutes post-dose the residual plasma glucose differed significantly ( $p < 0.001$ ) among the normal, IFG and diabetic individuals.



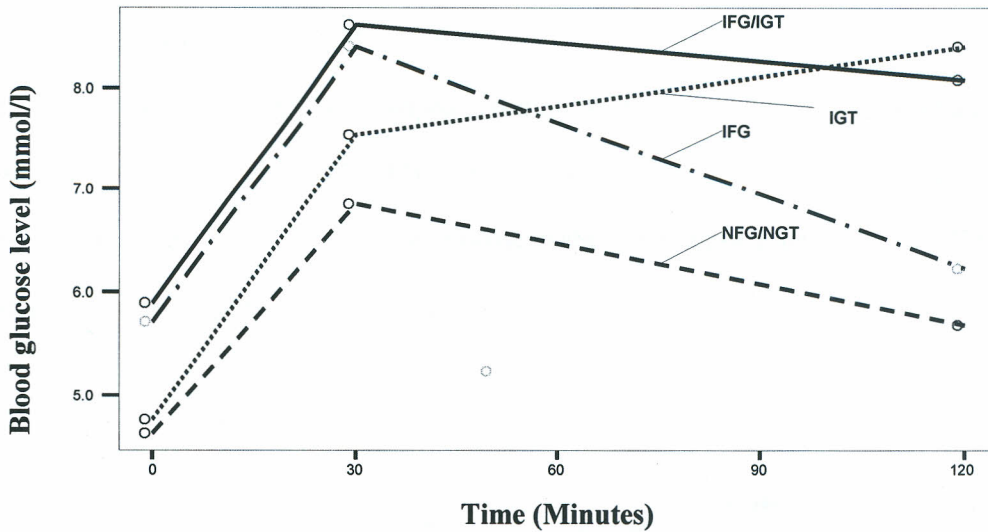
**Figure 4.5: Glucose Level with Time among Diabetes Status (IFG)**

The sugar metabolism of the IFG individuals was found to be consistently higher through out the glucose challenge period. There were significant difference in the FBG ( $p < 0.001$ ), 30-mins postprandial glucose ( $p = 0.002$ ) and the 2-hr postprandial glucose ( $p = 0.028$ ) among the individuals with IFG and the normal individuals. These tests were done using the T-test comparison of means.



**Figure 4.6: Gender Specific Sugar Metabolism Trends**

Among the communities, there were no significant differences in the fasting blood glucose level. The 30-mins ( $p < 0.001$ ) and 2hr ( $p < 0.001$ ) postprandial sugar level were both significantly different among the two communities. The Kipsigis community reported generally higher postprandial sugar among both males and females. This study also demonstrated that females from both populations were more likely to be glucose intolerant compared to the males ( $\chi^2 = 5.281$ ,  $p = 0.022$ ). This was however not observed when the populations were clustered per locality. The Luo the statistic indicated that there was likelihood that the males and females were equally distributed among the glucose tolerant and intolerant groups ( $\chi^2 = 1.204$ ,  $p = 0.273$ ) while among the Kipsigis community the opposite is true and therefore females were found to be more likely to be glucose intolerant compared to the males ( $\chi^2 = 4.445$ ,  $p = 0.035$ ).



**Figure 4.7 Glucose Level with Time among Pre-Diabetic Categories**

#### 4.2.5 Sub-section Summary

The objective of this section was determining variation in prevalence of T2D, IGT and IFG within and between the two communities living in the same climatic area. This study clearly illustrates different prevalence of IGT (2hr post-prandial glucose of between 7.8 mmol/L - 11.1 mmol/L) among two rural populations sharing similar environmental factors, except for variation in their dietary and cultural practices. The Luo community in Bondo district exhibited an IGT prevalence of 4.8%, while the Kipsigis community in Kericho district had a prevalence of 11.8%. It was also demonstrated that the females from both communities were more likely to be glucose intolerant compared to the males. We therefore reject the null hypothesis and conclude that despite living in the same climatic region the two populations are significantly different with reference to the prevalence of T2D, IFG and IGT.

### 4.3 Prevalence of Obesity, Overweight and Underweight and relation to prevalence of T2D, IGT and IFG

This section describes the body composition indices of the populations and correlates them to the prevalence of T2D, IGT, IFG and sugar metabolism pattern among the two communities. The trends of the glucose metabolism among the different BMI categories are been presented in Figure 4.3.

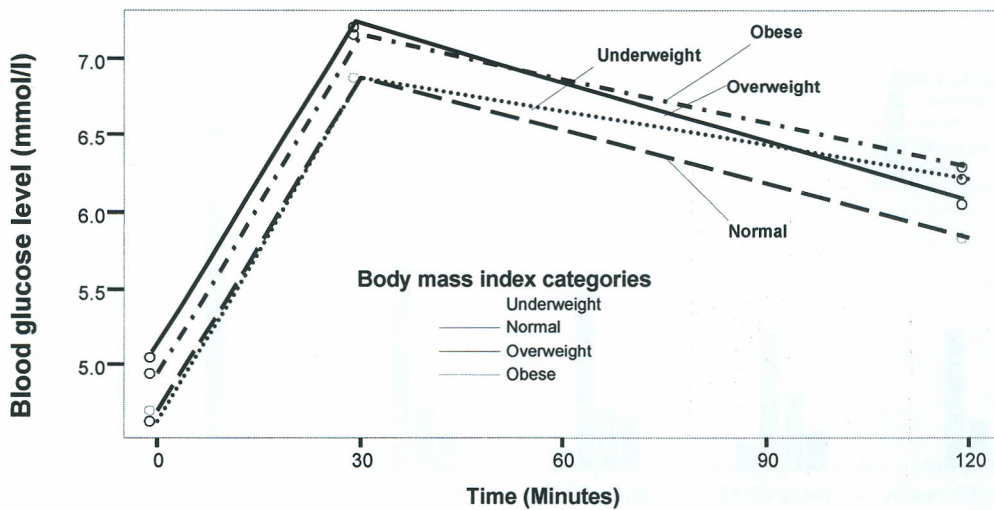


Figure 4.8: Glucose Level with Time among BMI Categories

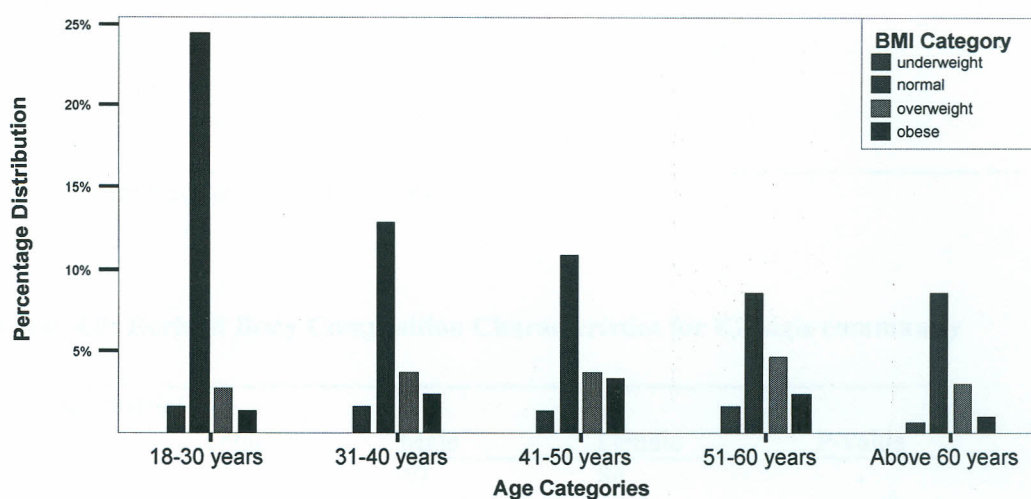
#### 4.3.1 Body Mass Indices (BMI)

The overall prevalence of obesity in the LVB was found to be 10.2% and among the males and females it was 3% and 15% respectively. The Luo people had an overall obesity of 9.3% while the Kipsigis had 11.3% obese.

Obese and overweight individuals were found to have a higher IFG and 30 minutes postprandial glucose though not significantly higher than the underweight and normal

BMI individuals. The underweight and obese individuals were found to have a higher 2-hr postprandial glucose level though not significantly higher than that of the overweight and normal individuals. This indicates that sugar metabolism is affected by both underweight and obesity.

The prevalence of underweight was 6.9% in the LVB. Among the males and females it was found to be 9.8% and 4.7% respectively. Among the age categories, the data is presented in Figure 4.9.



**Figure 4.9: Distribution of BMI per Age Categories**

**Table 4.7 Derived Body Composition Characteristics**

BMI RESULTS – COMBINED RURAL POPULATION				
BMI	Total	Male	Female	P-value
N	303	133	170	-
Mean $\pm$ SD	23.52 $\pm$ 4.31	22.45 $\pm$ 3.34	24.35 $\pm$ 4.78	<0.001 <sup>†</sup>
% underweight	6.9(n=21)	9.8(n=13)	4.7(n=8)	-
%normal	65.3(n=198)	71.4(n=95)	60.6(n=103)	-
%overweight	17.5(n=58)	15.8(n=21)	18.8(n=32)	-
%obese	10.2(n=31)	3.0(n=4)	15.9(n=27)	-

<sup>†</sup> Means compared using T-Test

There was significant differences in the BMI between the males and females ( $p < 0.001$ ). The females had a significantly higher BMI than the males. This was evident for both populations combined or independent as shown in table 4.7 ,4.8 and Table 4.9.

**Table 4.8: Derived Body Composition Characteristics for the Luo community**

Bondo District				
BMI	Total	Male	Female	P-value
N	150	64	86	-
Mean $\pm$ SD	23.12 $\pm$ 3.74	22.33 $\pm$ 2.71	23.71 $\pm$ 4.27	0.025 <sup>†</sup>
% underweight	6.7(n=10)	7.8(n=5)	5.8(n=5)	-
%normal	73.3(n=110)	79.7(n=51)	68.6(n=59)	-
%overweight	10.7(n=16)	10.9(n=7)	10.5(n=9)	-
%obese	9.3(n=14)	1.6(n=1)	15.1(n=13)	-

<sup>†</sup> Means compared using T-Test

**Table 4.9: Derived Body Composition Characteristics for Kipsigis community**

Kericho District				
BMI	Total	Male	Female	P-value
N	153	69	84	-
Mean $\pm$ SD	23.91 $\pm$ 4.79	22.55 $\pm$ 3.85	25.02 $\pm$ 5.20	0.001 <sup>†</sup>
% underweight	7.2(n=11)	11.6(n=8)	3.6(n=3)	-
%normal	57.5(n=88)	63.8(n=44)	52.4(n=44)	-
%overweight	24.2(n=37)	20.3(n=14)	27.4(n=23)	-
%obese	11.1(n=17)	4.3(n=3)	16.7(n=14)	-

<sup>†</sup> Means compared using T-Test

#### 4.3.2 Percentage Body fat

The percentage of body fat was determined using the Bioelectrical impedance scale. Among the two communities, the %BF results are presented in the table 4.8. Among the Luo it was found that there was a positive correlation between the %BF and the FBG ( $r=0.166$ ,  $p=0.043$ ) and the 2hr postrandial glucose level ( $r=0.256$ ,  $p=0.002$ ).

Therefore elevated %BF level among the Luo is a risk factor to elevated FBG and 2hr-postprandial glucose level. This also explains the significantly high % BF among the glucose tolerant individuals versus the glucose intolerant among the Luo ( $p=0.027$ ) and the Kipsigis ( $p=0.023$ ).

### 4.3.3 Hip Circumference

There were significant ( $p=0.001$ ) differences between the HC of the study participants of the two communities by gender as shown in table 4.8. It was noted that the Kipsigis had generally higher HC than the Luo for both gender, with the highest being among the females from both populations. The male HC was positively correlated ( $r=0.214$ ,  $p=0.013$ ) to the FBG but not the 2-hr postprandial glucose level, while among the females the HC was positively correlated to the 30-min postprandial glucose level ( $r=0.175$ ,  $p=0.024$ ). This explains the variation in the glucose intolerant individuals in terms of the HC. The HC was negatively correlated to the 2-hr postprandial glucose among those intolerant to glucose. This association infers that low hip circumference is an hindering factor to glucose metabolism among those who are glucose intolerant. These findings concur with findings by Christensen *et al.*, (2008) who found that a high HC was a confounding factor to glucose metabolism among the Kamba community of Kenya.

### 4.3.4 Middle Upper Arm Circumference (MUAC)

The mean MUAC results are presented in Table 4.10. There was significant difference in the mean MUAC values for the two populations. The lowest MUAC was reported for the Kipsigis men while the Kipsigis women had the highest MUAC value.

**Table 4.10: Mean Middle Upper Arm Circumference for the communities**

	Luo		Kipsigis	
	Male	Female	Male	Female
MUAC (cm)	28.02±3.51 <sup>ab</sup>	28.29±4.48 <sup>ab</sup>	27.02±2.94 <sup>a</sup>	28.60±4.41 <sup>b</sup>

The low MUAC among the Kipsigis men with highest WC reported in combination with elevated energy (Kcal) intake may explain the low physical activity levels reported. This infers that they have underdeveloped biceps brachii and triceps brachii muscles due to lack of upper body physical challenge both from leisure and work related activities. This scenario also explains the highest prevalence rate reported of T2D among the Kipsigis men compared to the other gender in the same community and the Luo community, as measured using the 2-hour postprandial glucose metabolism. In addition to this, MUAC was found to have a significant negative correlation ( $r=-0.247$ ,  $p=0.005$ ) with 2 hour postprandial glucose level while for females the opposite is true. The higher the MUAC for women from both areas the higher the residual 30 min postprandial glucose ( $r=0.157$ ,  $p=0.045$ ) and 2-hour postprandial glucose level ( $r=0.049$ ,  $p=0.535$ ).

#### 4.3.5 Waist Circumference

The WC was the highest among the Kipsigis male and the females compared to their Luo counterparts. Among the males there was insignificant positive relationship between the WC and the post-prandial glucose metabolism value as well as the fasting blood glucose. However, among the females there were significant ( $r=0.195$ ,  $p=0.012$ ) correlation between the WC and the 30min-post prandial glucose level. It was also

noted that there is a relatively strong positive correlation ( $r=0.292$ ,  $p=0.005$ ) between the WC and the blood cholesterol level.

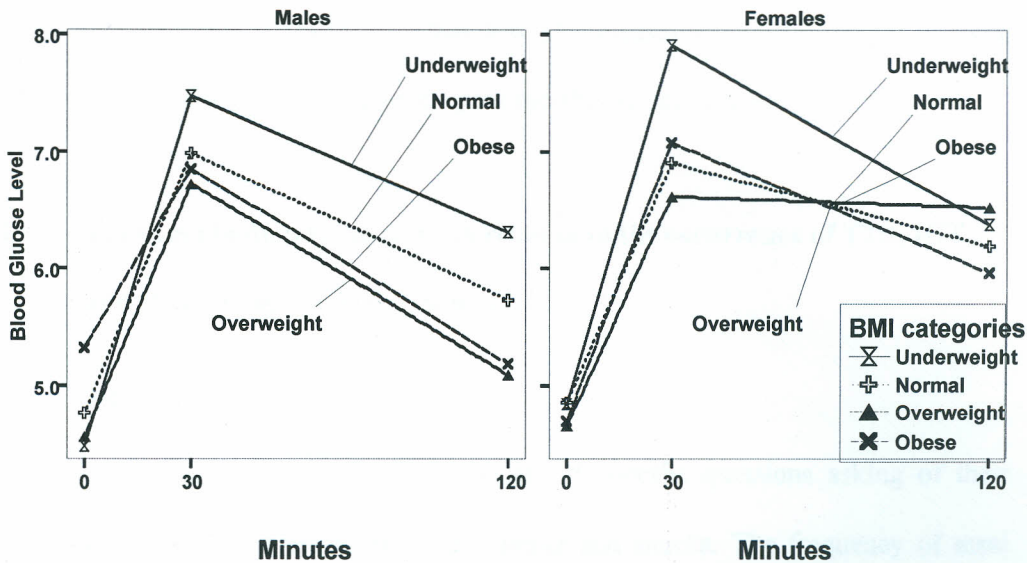


Fig. 4.11: GLUCOSE METABOLISM (OGTT) PER THE BMI CATEGORIES

The Waist to Hip Ratio (WHR) derived from the WC and the HC did not depict significant relationship with the post-prandial glucose metabolism for these populations. This could be attributed to the fact that the WHR is a derived ratio which could be affected by the different body shapes.

#### 4.3.6 Sub-section Summary

The objective of this section was to determine the variations in the anthropometric characteristics among the Luo and Kipsigis and correlate to them to the prevalence of T2D, IGT and IFG. Obesity was found to be a risk factor for high FBG and postprandial glucose levels. Underweight was also found to affect negatively the metabolism of glucose among this population. Among the females, it was found that

they have a significantly higher BMI than the males in both communities, thus explaining the high prevalence of IFG, IGT and T2D among the females. Elevated % body fat values were found to be a risk factor for high FBG and residual postprandial sugar levels. Lastly it was found that low HC measurements among the glucose intolerant people were a risk factor for poor metabolism of glucose.

#### 4.4 Variation in dietary patterns in relation to the occurrence of T2D, IGT and IFG among the two communities

##### 4.4.1 Frequency of Meal intake

The meal frequency was established by use of specific questions asking of their frequency of intake of breakfast, lunch, dinner and snacks. The frequency of meal intake is presented in Table 4.11.

**Table 4.11: Frequency of consumption of meals**

	Percentages	LUO		KIPSIGIS	
		Male	Female	Male	Female
Breakfast	Never	0	0	0	0
	Sometimes	21.9	18.6	1.5	1.2
	Always	78.1	81.4	98.5	98.8
Snack	Never	50	50	0	1.2
	Sometimes	45.3	47.7	100	98.8
	Always	4.7	2.3	0	0
Lunch	Never	0	1.2	0	0
	Sometimes	35.9	33.7	4.4	3.6
	Always	64.1	65.1	95.6	96.4
Supper	Never	0	0	0	0
	Sometimes	6.3	9.3	2.9	0
	Always	93.8	90.7	97.1	100

Always – 7 days in a week; Sometimes – 1-6 times in a week.

In the overall population it was identified that there was a positive correlation between the intake of both lunch ( $r=0.174$ ,  $p=0.003$ ) and snacks ( $r=0.133$ ,  $p=0.022$ ) to the 2 hour postprandial glucose. This implies that the more lunch and snacks taken the more the residual glucose in the blood after OGTT. Specifically, there were significant associations between the frequency of lunch ( $r=0.207$ ,  $p=0.007$ ) and snacks ( $r=0.181$ ,  $p=0.019$ ) intake among the females while among the men there were no correlations between meal intake and residual glucose level.

#### 4.4.2 Energy, Protein, Fat and PUFA intake

The energy, protein, fat and PUFA intake were estimated using the 24-hour recall method and analyzed using the nutria-survey programme. The descriptive of the food intake are shown in table 4.12

**Table 4.12: Food intake among the communities**

	Luo		Kipsigis		P-value
	Male	Female	Male	Female	
Energy (Kcal)	2929±953 <sup>a</sup>	2793±889 <sup>a</sup>	3575±780 <sup>b</sup>	3514±924 <sup>b</sup>	<0.001
Protein (g)	123±63 <sup>b</sup>	96±39 <sup>a</sup>	118±42 <sup>b</sup>	110±42 <sup>ab</sup>	0.004
Fat (g)	52±37 <sup>b</sup>	40±21 <sup>a</sup>	52±17 <sup>b</sup>	47±16 <sup>ab</sup>	0.003
CHO (g)	718±437 <sup>b</sup>	564±290 <sup>a</sup>	701±202 <sup>b</sup>	658±207 <sup>ab</sup>	0.006
Chol (mg)	110±19	78±108	74±77	86±137	NS
PUFA	2.4±6.3 <sup>b</sup>	1.4±2.2 <sup>ab</sup>	1.2±1.8 <sup>a</sup>	1.1±0.9 <sup>a</sup>	0.064

Note: means in the same row with the same letter are not significantly different.

There were significantly positive correlation between the amount of energy ( $r=0.142$ ,  $p=0.02$ ) taken per day and the 2 hour postprandial glucose level. However, there was significantly negative correlation ( $r=-0.128$ ,  $p=0.03$ ) between the intake of PUFA and

the postprandial sugar level. This implies that among the study population the more average daily energy intake the more the residual glucose level in the blood. However, increased intake of PUFA results in reduced residual blood glucose. Among the gender the males showed the negative response noted above while the females indicated a positive correlation with regard to PUFA intake. The protein ( $r=0.18$ ,  $p=0.02$ ), energy ( $r=0.203$ ,  $p=0.011$ ) and saturated fat ( $r=0.218$ ,  $p=0.005$ ) intake were positively correlated to fasting blood glucose level among the females only. These can be interpreted to mean that increased intake of the above food components results in females having higher residual blood glucose levels while this is not true in males. This may further be explained by the negative correlation between energy intake and total METs per week (Males:  $r=0.270$ ,  $p=0.003$ ; Females:  $r=0.159$ ,  $p=0.047$ ).

#### **4.4.3 Frequency of intake of Milk, Meat products, GLV, sugar, sugar cane, fats and oils**

The frequency of meat intake was found to be positively correlated to increasing energy ( $r=0.229$ ;  $p<0.001$ ), protein ( $r=0.226$ ;  $p<0.001$ ) and cholesterol ( $r=0.118$ ;  $p=0.042$ ). It was also observed that increased intake of meat was positively correlated to increasing waist circumference although increased intake of offals (*matumbo*) and eggs did not show the above relationship. However the increased intake of milk among the Kipsigis women was found to be positively correlated to increasing waist circumference ( $r=-0.234$ ;  $p<0.033$ ).

**Table 4.13: Frequency of food intake**

	Vegetables		Meat		Milk		Fish	
	L	K	L	K	L	K	L	K
Never	2.0	5.3	8.7	2.0	3.3	1.3	0	32.2
Once/mo	28.7	13.8	35.1	17.8	6.7	5.3	9.4	48.0
2-3times/mo	2.0	3.3	9.3	3.3	1.3	3.3	3.4	6.6
Once/wk	21.3	23.0	33.3	30.3	13.3	24.3	12.1	9.2
2-4times/wk	29.3	25.7	9.3	40.8	6.7	13.2	23.5	3.3
5-6times/wk	2.7	0.7	0.7	0	2.0	1.3	10.1	0
Once/day	8.6	8.6	2.0	4.6	47.3	19.1	30.2	0.7
2-3time/day	3.3	19.1	1.3	1.3	16.0	30.9	10.	0
4-6times/day	2.0	0	0	0	0	0	0	0
>6times/day	0.7	0.7	0	0	3.3	1.3	1.3	0

L – Luo, K – Kipsigis.

It was interesting to note that intake of insects was positively correlated with intake of exotic vegetables ( $r=0.242$ ;  $p<0.001$ ). The increased intake of insects was found to be positively correlated to increasing MUAC ( $r=0.124$ ;  $p=0.034$ ) and LDL ( $r=0.199$ ;  $p=0.018$ ). The intake of traditional leafy vegetables was found to be positively correlated to increasing WC ( $r=0.130$ ;  $p<0.024$ ).

Increased intake of exotic vegetables was found to have a profound negative correlation with the FBG ( $r=-0.139$ ;  $p=0.015$ ), 30 minutes postprandial glucose level ( $r=-0.130$ ;  $p=0.026$ ) and the 2 hour postprandial blood glucose level ( $r=-0.205$ ;  $p<0.001$ ). The intake of insects was also found to have a similar relationship as exotic vegetables on the 2 hour postprandial blood glucose level ( $r=-0.144$ ;  $p<0.013$ )

#### 4.4.4 Frequency of Fish and fish product consumption in relation to the prevalence of T2D, IGT and IFG

Their respective fish and fish product consumption was differing markedly, with 29.3% of the surveyed population in Bondo taking fish at least once a day with a mean consumption of 0.63g n-3FA, as compared to only 0.7% of the Kericho population, with a mean consumption of 0.02 g of n-3FA. The fish products are consumed in large quantities all year around Bondo district whereas in Kericho, they generally consume small quantities of fish. The Kericho population had a greater consumption of culturally preserved milk known as *mursik* as well as a high consumption of sugarcane, as the area of study is located within a sugar plantation belt. This compares well with a study that involved comparison of blood lipids and risk for Cardiovascular disease (CVD) among three populations, one of which had a higher consumption of marine products. These study subjects in Canada included the Québécois, the Cree of James Bay, and the Inuit of Nunavik. Significant differences in levels of CVD risk factors were found among these three populations. The Inuit showed the lowest risk status for CVD compared with the Cree and the Québécois, despite the high prevalence of cigarette smoking and obesity. Daily fish intakes varied significantly among the three groups, averaging 13, 60, and 131 g for the Québécois, the Cree, and the Inuit, respectively. Concentrations of EPA + DHA in plasma phospholipids were highest among the Inuit (8.0%), second-highest among the Cree (3.9%), and lowest among the Québécois (1.8%) (Dewailly *et al.*, 2003).

The significant negative correlation between 2 hr Post-prandial Glucose levels and consumption of DHA (C22:6), ( $r=-0.111$ ,  $p< 0.05$ ) was an indication that higher consumption levels of DHA significantly yielded lower levels of 2 hr post-prandial

glucose and lower levels of consumption of DHA yielded significantly higher levels of 2 hr post-prandial glucose. This was also the case between EPA and PUFA consumption and 2 hr Post-prandial Glucose levels at ( $r = -0.123$ ,  $p < 0.05$ ) and ( $r = -0.128$ ,  $p < 0.05$ ) respectively.

In both populations, the correlation between 2 Hr Post-Prandial Glucose and the consumption of Saturated Fats was ( $r = -0.002$ ,  $p = 0.973$ ), which clearly indicates no link between saturated fat consumption and the level of post-prandial glucose. The saturated fat ingested did not affect the level of post-prandial glucose. Higher proportions of saturated fatty acids intake have been associated with higher fasting insulin concentrations (Marshal *et al.*, 1997) and a lower insulin sensitivity index and consequently, higher risk of type 2 diabetes (Lovejoy and DiGirolamo 1992). On the other hand, there are several studies, which show no association between diabetes risk and total saturated fat intake (Feskens *et al.*, 1991; Salmeron *et al.*, 2001; Colditz *et al.*, 1992). It was important for this study to establish the risk of T2DM occasioned by saturated fat vis-à-vis polyunsaturated fats like O3FA.

Women in this study demonstrated higher prevalence of IGT than men ( $P < 0.05$ ), with the women among the Kipsigis of Kericho demonstrating an even higher prevalence than their Bondo counterparts (17.9%). The levels of post-prandial glucose among the women were also higher than those of men as seen in figure 4.2. In a study of over 60 year old women ( $N = 2,595$ ) in Goteborg Sweden, the prevalence of IGT was 14.4% and they also recorded higher values of BMI, waist girth and blood pressure. Among these women, 40% recorded having both IGT and FBG (Brohal *et al.*, 2006).

In Australia where the prevalence of abnormal glucose intolerance is one of the highest yet reported from a developed nation, 17.4% of the men and 15.4% of the women from a national sample of 11,247 were found to be suffering from IGT (Dustan *et al.*, 2002). Age and gender were confirmed to be very strongly correlated to impaired glucose tolerance as earlier observed in a study among rural and urban populations in Luzon, Philippines (Baltazar *et al.*, 2004).

#### 4.4.5 Consumption of n-3FA, PUFAs and Saturated Fats

Two components of n-3FA that are found in fish, Eicosapentaenoic Acid (C 20, 5) and Docosahexaenoic Acid (C 22, 6) were found to be consumed in Bondo at a mean of 0.29 g and 0.34 g per day respectively. In Kericho, the mean consumption for both EPA and DHA was, 0.01g for each. The consumption of both DHA and EPA was higher in Bondo than in Kericho ( $P < 0.001$ ). Other Polyunsaturated Fatty Acids (PUFAs) were found to be consumed at a mean of 1.91g and 1.14g for Bondo and Kericho respectively. Saturated fats were consumed at a mean of 3.8g and 6.7g for both Bondo and Kericho respectively. There was a highly significant difference between consumption of n-3FA, PUFAs and Saturated Fats in the two districts as indicated in the Table 4.13.

**Table 4.14: Consumption of EPA and DHA among the population**

Community	EPA (C 20,5) (g)	DHA (C 22,6) (g)	TOTAL n-3FA (g)	PUFAs (g)	Saturated Fats (g)
Luo	0.29	0.34	0.63	1.91	3.8
Kipsigis	0.01	0.01	0.02	1.14	6.7
P value	<0.001	<0.001	<0.001	<0.05	<0.001

Typical dietary recommendations for Omega 3 Fatty Acids are 0.3 to 0.5 g of EPA+DHA, which is met by the Bondo population in this study but not so for the Kericho population. The intake of total omega-3 fatty acids in the United States is approximately 1.6g, and of this, alpha-linolenic acid accounts for approximately 1.4 g, and only 0.1 to 0.2 g comes from EPA and DHA (Kris E *et al.*, 2002).

#### **4.4.6 Relationship Between 2 Hr Post-Prandial Glucose and the Consumption of DHA (C22,6)**

According to Pearson Correlation Coefficient, there was a significant negative correlation between 2 hr Post-prandial Glucose levels and consumption of DHA (C22,6), ( $r = -0.111$ ,  $p < 0.05$ ) in both populations. This is an indication that higher consumption levels of DHA significantly yielded lower levels of 2 hr post-prandial glucose and lower levels of consumption of DHA yielded significantly higher levels of 2 hr post-prandial glucose. For males the correlation between DHA consumption and 2 hr post-prandial glucose was ( $r = -0.226$ ,  $p < 0.05$ ) and ( $r = -0.049$ ,  $p = 0.533$ ) for females. The correlation between DHA consumption and 2 hr post-prandial glucose was not significant in females.

#### **4.4.7 Relationship Between 2 Hr Post-Prandial Glucose and The Consumption Of EPA (C20,5)**

The correlation between EPA consumption and 2 hr Post-prandial Glucose levels was ( $r = -0.123$ ,  $p < 0.05$ ), an indication that higher consumption levels of EPA significantly yielded significantly lower levels of 2 hr post-prandial glucose and lower consumption levels of EPA yielded significantly higher levels of 2 hr post-prandial glucose. For

males, the correlation between consumption of EPA and 2 hr post-prandial levels was very highly significant, at  $r=-0.237$ ,  $p<0.001$ ) and for females, there was also a negative correlation though it was not significant, at  $r=-0.056$ ,  $p=0.476$ ).

#### **4.4.8 Relationship Between 2 Hr Post-Prandial Glucose and The Consumption Of other Polyunsaturated Fatty Acids (PUFAs)**

There was an overall significant negative correlation between levels of 2 Hr Post-Prandial Glucose and the consumption of other Polyunsaturated Fatty Acids (PUFAs), among both populations ( $r=-0.128$ ,  $p<0.05$ ). Among the males, the correlation was  $r=-0.184$  at  $p<0.05$  and ( $r=0.010$ ,  $p=0.898$ ) among the females. These results indicate that among the females, there was no relationship between the levels of 2 Hr Post-Prandial Glucose and the consumption of other Polyunsaturated Fatty Acids (PUFAs).

#### **4.4.9 Relationship between 2 Hr Post-Prandial Glucose and The Consumption Of Saturated Fats.**

In both populations, the correlation between 2 Hr Post-Prandial Glucose and the consumption of Saturated Fats was ( $r=-0.002$ ,  $p=0.973$ ). It was ( $r=-0.043$ ,  $p=0.630$ ) for males and ( $r=0.1009$ ,  $p=0.166$ ) for females. These results clearly indicate no link between saturated fat consumption and the level of post-prandial glucose. The saturated fat ingested did not affect the level of post-prandial glucose.

#### **4.4.10 Sub-section summary**

The objective of this section was to determine the variation in food composition and consumption patterns and correlate to the prevalence of T2D, IGT and IFG among the two communities. The results indicate a large cross-ethnic difference in intake of n-3 fatty acids among the Bondo and the Kericho populations. It can be hypothesized that

the highly significant differences in prevalence of IGT observed between the Kipsigis community of Kericho and the Luo in Bondo is related to differences in lifestyle, with a special emphasis on dietary patterns. Therefore the null hypothesis is rejected and we adopt the alternate hypothesis that states that there are significant differences in the dietary practices among the two communities of the Lake Victoria Basin in Kenya.

#### **4.5 Physical activity patterns of the two populations**

##### **4.5.1 Physical Activity determination**

The physical activity status of the participants was determined using the International Physical Activity Questionnaire. This tool is made up of a set of standardized questions which aim at finding out an individual's use of time in the course of the previous week. Mainly the hours spend doing vigorous and moderate activities were recorded in addition to the hours spent walking and sitting down. These activities were further segregated to the job related physical activities and those done during their leisure time. The IPAQ is used only for estimating the physical activity of an individual but cannot objectively give the amount of energy expenditure. The objective gold standards methods are very expensive thus is a subjective IPAQ remains the only way of estimating physical activity of a population. The physical activity levels of the two populations were therefore estimated using the IPAQ, converted using the metabolic equivalence values and adjusted for weight.

**Table 4.15: Mean energy expenditure and time spend on various physical activities among the two communities of the LVB**

	<u>Kipsigis</u>		<u>Kericho</u>		P Value
	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>	
Energy Expenditure (Kcal)	2997.5 <sup>a</sup>	3029.5 <sup>a</sup>	3299.7 <sup>ab</sup>	3459.5 <sup>b</sup>	0.039
Activity Energy Expenditure	2337.1 <sup>b</sup>	1949.5 <sup>a</sup>	2667.6 <sup>b</sup>	2426.9 <sup>b</sup>	0.002
Hrs Vigorous Activity/week	18.94	14.88	19.71	16.78	NS
Hrs Moderate Activity/week	9.81 <sup>a</sup>	11.1 <sup>a</sup>	20.49 <sup>b</sup>	21.78 <sup>b</sup>	<0.001
Hrs Walking/week	9.39 <sup>b</sup>	4.32 <sup>a</sup>	15.35 <sup>c</sup>	16.41 <sup>c</sup>	<0.001
Hrs Spent sitting	17.35 <sup>a</sup>	17.75 <sup>a</sup>	23.26 <sup>b</sup>	22.95 <sup>b</sup>	<0.001

Means on the same row with same letter are not significantly different

In general it is observed that the estimation of time spend on various physical activities is higher among the Luo than among the Kipsigis.

#### **4.5.2 Time in hours spend on vigorous activities**

The mean time in hours spend on vigorous physical activities as reported by the two communities is presented in table 4.15. The time spend on vigorous physical activities was positively correlated to the high density lipoproteins among the Kipsigis males ( $r=0.315$ ,  $p=0.045$ ). Among the Luo males the time spend on vigorous physical activities was negatively correlated to the residual 2-hr postprandial glucose levels ( $r=0.298$ ,  $p=0.017$ ) and energy intake ( $r=-0.279$ ,  $p=0.045$ ). This relationship was not observed among the females from both areas as well as among the Kipsigis males. Overall there were no significant differences observed in the time spend on vigorous physical activities among the subcategories of the population such as age categories and the diabetic status i.e. normal, pre-diabetic or diabetic. This implies that they

reported equitable time spend on vigorous physical activities whether habitual, work-related or leisure time activities. Therefore it can be concluded that the two populations grouped by gender, locality and age categories do not spend different amounts of hours on vigorous activities. These results concur with findings by Frank *et al.*, 1999 who reported that fewer women do not take part in vigorous physical activities in the Nurses Health Study in the US.

#### **4.5.3 Time in hours spend on moderate activities**

Moderate physical activities were defined as activities that take moderate physical effort and make someone breathe harder than normal. Those included in this category were activities such as carrying light loads, bicycling at regular pace, running and harvesting sugarcane but excludes walking. The reported time spend on moderate physical activities is presented in table 4.15. The Kipsigis community reported significantly lower ( $p < 0.001$ ) time in this category than the Luo both among the males and the females. However within the two populations separately, it was observed that males spend lower amount of time on moderate physical activities though not significant from the females of their respective population. When segregated by age categories the females showered no significant differences in the moderate physical activities unlike the males who reported significantly different time spend in this category of physical activities. The younger males (18-30 years) reported the lowest mean time spend (12.54hrs per week) compared to the older males (51-60yrs) who accumulated an average of 20.65 hrs per week.

#### 4.5.4 Time hours spend walking

The time in hours spend walking was found to be significantly ( $p < 0.001$ ) different among the genders and locality as shown in table 4.15. The Kipsigis females were found to have reported the lowest mean time spend walking per week; while the Luo females reported the highest mean time spend walking per week. This can be directly associated with the higher overweight and obesity levels among the Kipsigis females as compared to the females from the Luo community. These findings also concur with Wing *et al.*, 2001 who found that there is an inverse dose response of length of time spend walking and the risk of T2D with increasing energy expenditure from walking appearing to confer comparable benefits with respect to reduction in risk of diabetes. This however does not explain the significantly ( $p = 0.024$ ) higher levels of low density lipoprotein among the Luo females compared to the less active (walking) Kipsigis females.

#### 4.5.5 Time in hours spend sitting

The average number of hours spend sitting (20.71 hours/week) in a week by the overall population in the LVB was found to be higher than the time spend doing vigorous (17.1 hours/week) and moderate (15.2 hours/week) activities with the least time overall spend walking (11.0 hours/week). The amount of time spend sitting was found to be significantly ( $p < 0.001$ ) higher among the Luo as compared to the Kipsigis in both gender. This may explain the higher levels of LDL cholesterol levels measured among the Luo females as compared to their Kipsigis counterparts. Findings from this study do not concur with Strong *et al.*, 2005 who found out that in many observational studies there was a null effect of the physical inactivity on the LDL cholesterol levels among school-age youth.

The length of time spend sitting is hereby used as an indicator of physical inactivity among the population. The association between the elevated energy intake and long hours spend sitting by the Luo community does not explain the significantly ( $p < 0.001$  males and  $p < 0.001$  females) higher 2-hour post prandial glucose and the significantly ( $p = 0.029$  males and  $p = 0.014$  females) higher 30 min glucose level for both gender compared to their Kipsigis counterparts who reported to spend less hours sitting but with a significantly ( $p < 0.001$ ) higher energy intake levels for both gender.

#### **4.5.6 Activity energy expenditure**

The Activity Energy Expenditure (AEE) mean values were found to be 2526 Kcal per day among the Luo while for the Kipsigis the AEE was significantly lower ( $p = 0.003$ ) at 2124 Kcal. The total MET values were also found to be significantly lower ( $p < 0.001$ ) among the Kipsigis compared to the Luo community. This contradicted with the number of hours spend sitting with the Luo sitting significantly longer ( $p < 0.001$ ) hours per week compared to the Kipsigis. This could be attributed to underreporting of physical activities done using the IPAQ.

Among the gender in both regions combined, the males were found to have a significantly higher ( $p = 0.025$ ) AEE than the females. However the total MET values and the hours spend sitting were not significantly different within the gender. The total MET values among the Kipsigis differed significantly ( $p = 0.019$ ) between the gender with the men being significantly higher than the women.

#### **4.5.7 Sub-section summary**

The objective of this section was to determine the differences time spend on various physical activities of the two communities and their relationship to the prevalence of T2D, IGT and IFG. A major drawback of the IPAQ method of estimation of physical activities causes the interpretation of these results with caution due to inherent underestimation and overestimation errors. The disparities in the reporting of the various times spend on different physical activities further emphasizes the unreliability of IPAQ in determining the physical activity levels of populations but only provides subjective estimates. However it should be appreciated that it was the best available tool at the time of data collection for this study. It is therefore recommended that a new more effective tool for estimating physical activities for large populations and especially in rural settings.

This study found that there were significant differences among the two communities in the time they spend doing various physical activities. The null hypothesis is therefore rejected while the alternative hypothesis, that there are significant differences in the physical activity patterns of the two communities who live in the same climatic area but with different socio-cultural patterns is accepted.

#### **4.6 Distribution of blood type within the two communities in relation with Type II Diabetes**

The distribution of the population by blood type is concurrent with the Africa distribution of blood groups. Blood type AB was found to be the rarest while type O was found to be most abundant among the two communities. These findings were

found to be in tandem with other results from Africa as shown in Table 4.16 and Table 4.17.

#### 4.6.1 Blood Type Distribution

There were many people with blood Type A in Kericho district (n = 50) as compared to Bondo (n = 37). There are also more with blood type O in Kericho district (n = 77) as compared to Bondo district (n = 64). There were many people with blood type AB (n = 6) in Kericho as compared to Bondo district n = 4). Nevertheless, there were equal numbers of people with blood type B in both Bondo (n = 32) and Kericho (n = 32) districts.

**Table 4.16: Blood type distribution among the study population**

	Luo (n = 151)	Kipsigis (n = 153)	Total (n = 304)
Blood group A			
% Male	33.8 (n=22)	39.1 (n=27)	36.6 (n=49)
% Female	17.4 (n=15)	27.7 (n=23)	22.5 (n=38)
Blood group AB			
% Male	4.6 (n=3)	4.3 (n=3)	4.5 (n=6)
% Female	1.2 (n=1)	3.6 (n=3)	2.4 (n=4)
Blood group B			
% Male	15.4 (n=10)	18.8 (n=13)	17.2 (n=23)
% female	25.5 (n=22)	22.9 (n=19)	24.3 (n=41)
Blood group O			
% Male	46.2 (n=30)	37.7 (n=26)	41.8 (n=56)
% female	55.8 (n=48)	45.8 (n=39)	50.9 (n=87)

Generally, there were more people with blood type O in both regions (N = 141), followed by blood type A (N = 87), then followed by blood type B (N = 64) and least distributed was blood type AB (N = 10).

**Table 4.17: Blood type distribution among some populations of the world**

Blood type	Distribution (%) Kenya	Distribution (%) Punjab (India)	Distribution (%) Nigeria
A	28.8	21.2	20.3
AB	3.3	7.6	3.7
B	21.2	40.8	19.6
O	46.7	30.5	49.8

It was observed that most people in the regions under study had blood Type O (46%) followed by blood type A (28.8%), B (21.2%) and there very few people with blood type AB. These values compared well with what has been reported in other countries. The high percentage of blood group O in the populations provides an advantage in terms of availability of blood for transfusion. Table 4.18 presents the distribution of T2D, IGT among the two communities of the Lake Victoria Basin.

**Table 4.18: The Prevalence of Diabetes on Different Blood Types**

Community	Blood Type*	% Normal	% IGT	% Diabetic
Luo	A +	94.3	5.7	0
	B +	93.8	3.1	3.1
	O +	93.4	5.3	1.3
	AB +	75	25	0
Kipsigis	A +	94.0	4	2
	B +	87.1	12.9	0
	O +	80.6	17.7	1.6
	AB +	83.3	16.7	0

\* Blood Type with Rhesus Factor

In Bondo district, there was a high diabetic prevalence in the blood type B with a percentage of 3.1% (n=32) followed by blood type O with a percentage of 1.3 % (n=77). There were no diabetic cases in blood Types A and AB in this district. However there were many IGT in blood type AB with a percentage of 25% (n=4) followed with high percentages in blood types A and O of 5.7% and 5.3% respectively. From the N values and the IGT and diabetics it is clear that the blood types A and O are at a higher risk of developing diabetes in this region.

In Kericho district, there were more diabetic cases in blood type A with a prevalence of 2.1 % (n=50) followed by blood type O with a prevalence of 1.6 % (n=64).there no diabetic cases in blood types B and AB in this district. Nevertheless, there were high IGT cases in blood types O negative with a 50 % prevalence (n=4), followed by blood types O positive with a prevalence of 17.7 % (n=64) and blood type AB with a prevalence of 16.7% (n=6). From this data it was conclude that the blood type O is at a higher risk of developing diabetes in this district.

From both districts, it was observed that there were many people with blood type O positive (n=138) followed by blood type A positive (n=85), followed by blood type B positive (n=63), followed by blood type AB positive (n=10), then O negative (n=3), then A negative (n=2) and B negative (n=1).

The trends of blood glucose metabolism are shown in Fig 4.10.

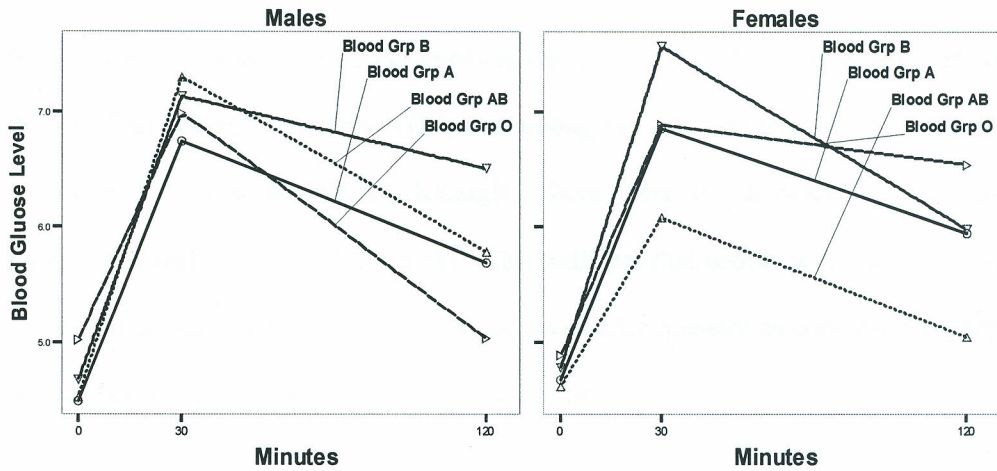


Figure 4.10: Blood Type differences in glucose level with time after OGTT

#### 4.6.2 Blood Group A

There was no impaired FPG cases in blood type A among the Luo ( $n = 37$ ) whereas there were many impaired FPG cases with blood type A among the Kipsigis with a percentage of 4% ( $n = 50$ ). There was also more IGT cases among the Kipsigis in blood type A with a prevalence of 4% ( $n = 50$ ) while it was 2.7% among the Luo ( $n = 37$ ) of the same blood type. There were also many diabetic cases among the Kipsigis in blood type A (2%),  $n = 50$  and no diabetic cases among the Luo (0%). This data indicated that people with blood type A from the Kipsigis community were at a higher risk of developing and being diabetic as compared with people with blood type A from the Luo.

#### **4.6.3 Blood Group AB.**

There were no cases of impaired FPG in blood type AB among the Luo community (0%) while there were many FPG impaired cases among the Kipsigis with blood type AB (16.7%). There were 25% IGT cases among the Luo community (N = 4) and a 16.7% IGT cases among the Kipsigis. There were no diabetes cases in both populations with IGT of  $>11.1$  mmol/L. This indicates that people with blood type AB among the Kipsigis were at a higher risk of developing diabetes as compared to people with the same blood type from the Luo community.

#### **4.6.4 Blood Group B.**

There were 3.1% of the Luo people with blood type B, who had impaired FPG (n = 32) and no cases were reported among the Kipsigis community. There were also more diabetic cases with an FPG impaired of  $> 6.1$  mmol/dL in blood type B among the Luo, with a prevalence of 6.3% with no diabetic cases reported within this blood type among the Kipsigis. There were more IGT cases among the Kipsigis with a prevalence of 12.5% while the prevalence was 3.3% among the Luo community. There were no IGT diabetic cases of g/c concentration  $>11.1$  mmol/dL in blood type B. This indicates that more people with blood type B in the Luo community were at a higher risk of developing diabetes as compared to people of the same blood type from the Kipsigis community although the number of IGT cases as extremely high among the Kipsigis.

#### **4.6.5 Blood Group O.**

There were no FPG impaired cases among the Luo but among the Kipsigis there were 3.8% FPG impaired cases with blood type O. There were also no FPG diabetic cases among the Luo but among the Kipsigis with blood type O there were 2.6% being

diabetic. However, there were more IGT cases among the Luo at 12.5% (N = 77) as compared to 5.3% among the Kipsigis community with blood type O.

#### 4.6.6 Sub-section summary

The objective of this section was to determine the effects of blood type on post-prandial sugar metabolism within and between two communities of the lake Victoria Basin. These results indicate that there no significant differences in the metabolism of glucose between the different blood types. The researcher therefore upholds the null hypothesis that there are no significant differences in the sugar metabolism among the different blood in the two rural populations.

#### 4.7 Lipid analysis and glucose metabolism

Lipid analysis was done through the analysis of the serum collected for the levels of the High Density Lipoproteins (HDL), Triglycerides (TRI), Cholesterol (CHOL) and Low Density Lipoproteins (LDL). There was a high percentage of 47.2% and 65.7% who were with risk indicator level of the HDL cholesterol (< 0.9 mmol/l for males and <1.16mmol/l for females) (Table 4.19)

**Table 4.19: Mean Lipid values by gender.**

LIPID	<u>Luo</u>		<u>Kipsigis</u>		P Value
	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>	
LDL	2.34±1.67	2.51±1.24	2.21±0.75	1.04±0.48	NS
HDL	0.86±0.37	1.01±0.57	1.04±0.35	1.06±0.32	NS
CHOL	3.63±1.63	3.97±1.41	3.74±0.79	3.59±0.85	NS
TRI	0.89±0.51	1.08±0.68	1.11±0.63	1.03±0.48	NS
NS	No Significant Differences				

There were no significant differences observed in the lipid levels among the males and the females of both populations as shown in table 4.19.

The were consistently higher distribution of dyslipidemia among the Luo as compared to the Kipsigis who reported lower values with no cases of elevated LDL and Elevated Chol being observed (Table 4.20)

**Table 4.20: Percentage distribution of dyslipidemia among the communities**

Lipid	Luo	Kipsigis
Elevated LDL	2.9%	0%
Elevated CHOL	2.6%	0%
Elevated Triglycerides	6.4%	4.0%

It is however observed that the cholesterol and LDL showed consistent increase with age among the two communities as shown in Table 4.21.

**Table 4.21: Mean Cholesterol and LDL levels by age categories**

Age category	Cholesterol	LDL
18-30 years	3.14 <sup>a</sup>	1.78 <sup>a</sup>
31-40 years	3.61 <sup>ab</sup>	2.06 <sup>ab</sup>
41-50 years	3.88 <sup>abc</sup>	2.45 <sup>ab</sup>
51-60 years	4.44 <sup>c</sup>	2.68 <sup>c</sup>
> 60 years	3.94 <sup>bc</sup>	2.65 <sup>c</sup>

Means in the same column with the same letter are not significantly different

There were significant differences in the means of the cholesterol and LDL among the age categories but there were no significant differences in the mean Triglycerides and HDL levels. Among the females it was found that there was a significant positive correlation between the cholesterol ( $r=0.292$ ,  $p=0.005$ ), LDL ( $r=0.26$ ,  $p=0.03$ ) and triglyceride level ( $r=0.352$ ,  $p=0.001$ ) while the levels of HDL did not correlate to the waist circumference. It was also noted that there were significant relationship between the age and cholesterol level ( $r=0.314$ ,  $p=0.005$ ) and LDL ( $r=0.341$ ,  $p=0.004$ ) among the females from the two populations. This infers that older women have a higher cholesterol level than the younger women yet this was not true for the men from the study population. The cholesterol level of obese individuals was found to be significantly higher than for overweight, normal and underweight individuals as shown in Table 4.22. This was also found to be true for the triglycerides but not for the LDL and HDL. These results indicate that obesity is a risk factor for undesirable elevated body triglyceride levels.

**Table 4.22: Mean Cholesterol and Triglycerides levels by BMI categories**

Lipid	Underweight	Normal	Overweight	Obese
Triglycerides	1.14±0.52 <sup>ab</sup>	0.93±0.43 <sup>a</sup>	1.13±0.63 <sup>ab</sup>	1.46±0.85 <sup>b</sup>
Cholesterol	3.22±1.34 <sup>a</sup>	3.54±1.00 <sup>ab</sup>	4.12±1.21 <sup>ab</sup>	4.37±1.28 <sup>b</sup>

Means on the same row with the same letter are not significantly different

Elevated triglycerides have been reported to be a strong independent predictor of a person's risk for stroke (Sacco *et al.*, 2006). The levels of triglycerides was found to be significantly associated ( $\chi^2=25.21$ ,  $p<0.001$ ) with increased incidence and

prevalence of T2D and its risk factors among the Luo while this was not true for the Kipsigis community.

The Cholesterol ( $\chi^2=89.42$ ,  $p<0.001$ ) and the LDL ( $\chi^2=16.82$ ,  $p=0.032$ ) were similarly associated with the prevalence of T2D and risk markers among the Luo only. Elevated cholesterol levels are also a risk factor for hardening of the arteries. Hardening of the arteries is a disorder in which arteries become narrowed because cholesterol deposits (atherosclerosis) is first deposited on the inside walls of the arteries, then becomes stiffened by fibrous tissue and calcification (arteriosclerosis). As this plaque grows, it narrows the lumen of the artery, thereby reducing both the oxygen and blood supply to the affected the body organs. The plaque may eventually severely block the artery, causing death of the tissue supplied by the artery (Fuster, 2007).

#### **4.7.2 Sub-section Summary**

The objective of this section was to determine the differences in the lipid profile as related to physical inactivity, prevalence of T2D, IGT and IFG among the Luo and Kipsigis of the Lake Victoria Basin. The levels of triglycerides was found to be significantly associated ( $\chi^2=25.21$ ,  $p<0.001$ ) with increased incidence and prevalence of T2D and its risk factors among the Luo while this was not true for the Kipsigis community. The Cholesterol ( $\chi^2=89.42$ ,  $p<0.001$ ) and the LDL ( $\chi^2=16.82$ ,  $p=0.032$ ) were similarly associated with the prevalence of T2D and risk markers among the Luo only.

#### 4.8 Chapter Summary

The prevalence of T2D in the rural setting in Lake Victoria Basin of Kenya stands at an overall of 2.6% of the population and 1.5% vs 3.5% for males vs females respectively. The overall energy intake was higher among the Kipsigis than that of the Luo for both males and females. This free living rural population reported to have a high PAL with only a few reporting to be physically inactive. The activity energy expenditure was however significantly higher among the Kipsigis. There were significant differences in the food intake and dietary patterns among the two populations even though they live in the same climatic region. There were also significant associations among the lipid profiles of the Luo people with the prevalence of T2D and its risk markers yet this association was not observed among the Kipsigis. However there were no significant differences in the prevalence of T2D and its risk markers among the different blood types amongst both communities.

**Table 4.23: Relational analysis showing significant predictors of glucose intolerance**

Variable	B	SE	OR	p-Value
Elevated LDL	12.27	1.91	4.68	<0.001
Suspect Triglycerides	3.02	1.40	20.51	0.031
Sedentary Lifestyle	2.42	1.68	11.24	0.025
Gender (Female)	1.28	0.81	3.61	0.112

B - Estimated multinomial logistic regression coefficient

SE – Standard Error;

OR – Odds Ratio

Further relational analysis indicated that among the two rural communities overweight, elevated LDL, suspect levels of triglycerides and sedentary lifestyle were significant predictors of T2D and its risk factors as showed in Table 4.23. In addition, males were at more risk than females in the two rural communities.

The analysis of the significant predictors of glucose intolerance was done using the multinomial logistic regression. Therefore women with elevated LDL levels, increased Triglycerides, sedentary lifestyles (< 20 hours walking per week) were at risk of glucose intolerance as compared to those not in these categories.

## CHAPTER FIVE

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

This chapter presents the summary of the main results, conclusions, implications of findings, and recommendations for policy, further research and healthy living.

#### 5.2 Conclusion by objective

There were significant differences in the prevalence of T2D, IGT and IFG between the two communities. The Kipsigis had a higher prevalence of IGT despite the lower overall prevalence of T2D, while the females from both populations had higher prevalence of T2D and its risk markers. There were large cross-ethnic differences in the food intake and dietary patterns among the two communities. This is associated to the differences observed in the prevalence of T2D and its risk markers between the two rural communities from the same climatic region. The physical activity patterns were found to differ significantly between the two populations/ communities. The hours spend sitting as a proxy for physical inactivity were significantly different by both gender and locality. Generally Energy expenditure was estimated to be higher in the females than the males in both communities, while the hours spend sitting was surprisingly also higher in the females from both areas.

The presence of obesity and underweight were found to be risk factors for impaired postprandial glucose metabolism. There was generally higher mean BMI among the females from both populations and this may explain the elevated levels of T2D and its risk factors among the women. High % BF levels were found to be risk factor for having higher FBG levels. There were significant differences in the means of the

cholesterol and LDL among the age categories but there were no significant differences in the mean Triglycerides and HDL levels. The levels of triglycerides were found to be significantly associated with increased incidence and prevalence of T2D and its risk factors among the Luo while this was not true for the Kipsigis community. The Cholesterol and the LDL were similarly associated with the prevalence of T2D and risk markers among the Luo only. This infers that the Luo individuals displayed more risk to develop T2D or its risk markers if they have elevated TG, Chol and/or LDL. There were no significant differences in the prevalence of T2D or any of its risk markers among the individual's blood type categories.

### **5.3 Implications of findings**

Having disseminated the findings and as an effect of the advice during the study period, the main implication of these findings is overall change of attitude towards physical activity and diet as relates to T2D. It is important that the health institutions in the concerned region have the statistics of the cross-sectional survey as per the study time for their input in decision making as regards non-communicable diseases.

### **5.4 General Recommendations**

Given the strong association between lifestyle behaviours and the prevention and treatment of T2D, it is important that greater research attention be directed at issues related to development of healthful eating and physical activity habits and strategies for modifying unhealthy behaviours. The focus should be on the ways to change eating and physical activity behaviour both from an individual perspective and a broader environmental perspective. Blood types A and O are at a higher risk of being diabetic due to the high cases of impaired glucose metabolism. People with blood type B are at a higher risk of developing T2D if they consumed a lot of meat and fat. It is

recommended therefore that they should manage their diet intake very closely to avoid foods that predispose them to elevated blood sugar levels.

Other Recommendations include

- It is recommended that when inferring results from communities living in the same climatic region, the prevalence of T2D and its risk markers may differ. Health practitioners should therefore consider socio-cultural backgrounds for prognosis and management of T2D and its risk markers.
- Individual's dietary pattern is of great influence to health especially in relation to T2D and its risk factors. It is recommended that during prognosis of T2D, the individual's dietary patterns be considered as a confounding factor. A high overall protein percent intake in the diet has desirable effects in the management of blood sugar metabolism. Increased intake of vegetables was found to have protective effects against glucose intolerance.
- The energy expenditure significantly contributed to the differences in the prevalence of T2D and its risk markers. It is therefore recommended that the time hours spend sitting (physical inactivity) be drastically reduced by the overall populace living in the Lake Victoria Basin to mitigate the prevalence of the T2D and its risk markers in the region. It is further recommended that the methods for estimation of physical activity levels be improved at population level so as to access accurate and reliable estimates of energy utilization in the various physical activities especially in Africa.
- Increasing BMI, % BF and HC independent of age and sex are risk factors for glucose intolerance. It is recommended that maintaining a healthy BMI range is necessary to avoid impaired glucose metabolism. This is clearly more important in females especially individuals with elevated %BF. Managing

%BF in desirable ranges can be achieved by encouraging low intensity physical activity lasting for long periods of time. Hip Circumference which is related to the %BF can be used as a proxy indicator especially for population screening.

### **5.5 Recommendations for Policy**

Guidelines for use of girth measurements as a primary prevention tool and for awareness promotion in remote villages far from health facilities should be developed and implemented at the primary health care level. Cut-offs of girths to be developed for males and females in Sub-Saharan Africa for purpose of use in population studies especially for free living populations.

Other recommendations for policy include:

- Reclassification of populations into objectively determined health-lifestyle related clusters to form basis for health research in Africa
- Further research done on the level of penetration of urbanization or westernization in our rural setting and adjust accordingly to avert the T2D pandemic

### **5.6 Recommendations for health living**

Elevated BMI, %BF and WC is discouraged among all persons for purposes of managing the body glucose metabolism. Increasing the protein percentage and vegetable intake in the diet is recommended for all age groups and both genders. Furthermore sedentary lifestyles should be avoided especially for men from these two communities who are at risk for glucose intolerance.

## 5.7 Recommendations for Further research

Longitudinal research is needed to identify risk and protective factors for childhood overweight and for weight gain during adulthood. These designs should include samples that allow comparisons across racial and ethnic groups. Objective measurements of PA could be very important in predicting accurately. IPAQ and other questionnaire related determination of physical activity overestimates the physical activity level. Other recommendations for further research include:

- Future research to use GPAQ instead of IPAQ and Customization of nutrition analysis packages to incorporate local foods
- Further research on effect of protein on glucose metabolism in controlled lab environment.
- Lab trials for exercise prescription for pre-diabetics to avoid progression to diabetes

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#### Introduction

Type 2 diabetes mellitus has become characterized by malnutrition as well as by over-nutrition. It has increased in many countries, with complications such as cardiovascular disease, blindness, kidney failure and limb amputation. Differences in racial, social and geographical distribution suggest a complex aetiology of diabetes. This document reports the findings of a meeting on the topic of malnutrition during management of

#### Procedure

At the first visit you will be questioned about your diet, alcohol, tobacco, weight, economic and physical activity history. A clinical and physical examination will be done by the study medical personnel for signs and symptoms of diabetes. You will be weighed and measurements for height, arm and waist circumference and skin fold thickness will be measured. A blood sample will be taken by means of pricking your finger. You will be asked to return to the study after 2 weeks.

#### Conclusions

Any records relating to your participation in the study will be confidential. Your name will not be divulged to anyone outside the study. The results of the study will be published in the scientific literature. Participation in this study is voluntary. If you do not wish to participate in the study, you may withdraw at any time without any consequences. If you do not wish to participate in the study, you may withdraw at any time without any consequences. If you do not wish to participate in the study, you may withdraw at any time without any consequences.

#### Results

## **APPENDICES**

### **Appendix 1: Consent form**

#### **Prevalence of Type 2 Diabetes and Its Risk Factors among the Luo and the Kipsigis of the Lake Victoria Basin**

##### **Introduction**

Type 2 diabetes mellitus is a disease characterized by malfunction in insulin secretion or action. If left untreated, diabetes causes health complications such renal diseases, heart complications and eye complications. Differences in cultural, social and economic factors are thought to contribute to the development of diabetes. This study will help us understand how lifestyle changes can be modified during management of diabetes.

##### **Procedures**

At the first visit you will be questioned about your past medical, dietary, social, economic and physical activity history. A clinical and physical examination will be done by the study medical personnel for signs and symptoms of diabetes. You will be weighed and measurements for height, arm and waist circumference and skin fold thickness will be determined. A blood sample will be taken by means of pricking your middle finger to diagnose diabetes.

##### **Confidentiality**

Any records relating to your identity and test results will remain confidential. Your name will not be divulged in any report of the results, and you will receive a copy of this consent form. Participation in this study is entirely voluntary and if you no longer want to take part in the study, you may stop at any time. You are welcome to ask questions both before consenting and at any time thereafter. Members of the research team are available to answer your questions any time during working hours.

##### **Benefits**

By agreeing to participate in this study, you will receive free medical check-up and advice on ways to prevent and/or manage diabetes. Those found ill will be referred to hospitals for further treatment.

**Subjects Statement**

I have understood the above information which has been fully explained to me by the investigator, and I voluntarily consent to participate.

Name of district \_\_\_\_\_

Name of participant \_\_\_\_\_

Signature of Participant \_\_\_\_\_ Date \_\_\_\_\_

**Appendix 2 : Social-economic questionnaire**

**Recruitment Centre** ..... **Date**.....**Time** .....

**Subject Name.** ..... **Subject No.** ..... **Sex**.....

1. What is your date of birth?  
\_\_\_\_\_
2. What is your marital status?
  1. Single (**skip to Que. 5**)
  2. Married
  3. Separated (**skip to Que. 5**)
  4. Divorced (**skip to Que. 5**)
  5. Widow/Widower. (**skip to Que. 5**)
3. Is your partner working?
  1. Yes
  2. No **Skip to Que. 5**
4. If **yes to no. 3**, what is your partner's occupation?  
\_\_\_\_\_
5. What is the highest level of Education you have attained?
  - 1 None
  - 2 Primary
  - 3 Secondary -'O' Level
  - 4 Advanced Level -'A' Level
  - 5 College / University
  - 6 Other (Specify).....
6. What mode of transport do you use to work this season?
  - 1 Car – Privately owned / lift/Company
  - 2 Public means – Matatu /Bus
  - 3 Taxi
  - 4 Bicycle
  - 5 Walking
7. How would you describe your working status?
  1. Employed
  2. Self-employed
  3. House wife/husband
  4. Unemployed
  5. Other (Specify).....
8. If employed, what is your Occupation/ job category?
  - 1 Managerial
  - 2 Support staff
  - 3 Secretarial

- 4 Temporary/casual
- 5 Other (specify).....

9 If self-employed, specify your occupation?

---

10 Do you have any other source of income?

- 1. Yes
- 2. No **Skip to Que 12**

11 If **yes, to no. 10** which one(s)?

- a).....
- b).....
- c).....

12 Approximately how much money do you spend per month on the following items at home in Ksh?

Food	Clothes	General house hold commodities	Health -care	Water, electricity/cooking fuel	Transport to and from work	School Fees	Other

13 Who owns the house you live in?

- 1 Self / Spouse – built
- 2 Inherited
- 3 Rental
- 4 Other (Specify).....

14 If **self/spouse built in no. 10**, who owns that land?

- 1. Self / Spouse
- 2. Inherited
- 3. Rental
- 4. Other (Specify).....

15 What is the acreage of the land you live in?

---

16. What is your source of water for domestic use?

- 1 Piped Water (council)
- 2 Bore hole / Well
- 3 River / Stream
- 4 Trucked in water
- 5 Pool/Pond
- 6 Gutter water in tank
- 7 Other  
(Specify).....
- .....

17. Approximately what is the distance from your house to the water source in meters?

- 1) Inside the house
- 2) Under 50 m
- 3) 50 – 500m
- 4) 500 – 1000m
- 5) Over 1000 m

18. Do you have any of the following in your house?

- (1) TV
- (2) Radio
- (3) Video/DVD/VCD
- (4) Refrigerator
- (5) Cooking Stove
- (6) Sofa

19. How many people live in your homestead?

---

20. Do you own any domesticated animals?

- 1. Yes
- 2. No **Skip to Que. 20**

22. Which animals and how many of each?


23. In which area were you born?

---

24. For how long have you lived in this area?

---

25. Observe what the house is made up of, and record about the following....

Roof.....Walls .....Floor.....

**Appendix 3: Type 2-diabetes Health Assessment Form** ID \_\_\_\_\_

No. \_\_\_\_\_

Name of subject \_\_\_\_\_ Age \_\_\_\_ in years  
Sex \_\_\_\_\_

Q1) What jobs have you done in your life?  
\_\_\_\_\_

Q2) Are you suffering from any sickness now? Yes \_\_\_\_ No \_\_\_\_ If Yes, which one(s) \_\_\_\_\_ How long? \_\_\_\_\_

Q3) Are you on any medications now? Yes \_\_\_\_ No \_\_\_\_ If Yes, which one(s) \_\_\_\_\_ How long? \_\_\_\_\_

Q4) Have you ever been admitted into hospital? Yes \_\_\_\_ No \_\_\_\_  
If yes, what was the problem(s) \_\_\_\_\_

Q5) Do you suffer from any of the following?

	Yes	No
1 Severe thirst		
2 Frequent passing of urine		
3 Numbness of feet		
4 Numbness of fingers		
5 Pins and needles		
6 Severe hunger		
7 Loss of appetite		
8 Wounds on your legs		

Q6) Do you smoke? Yes \_\_\_\_ No \_\_\_\_

If yes, how many cigarettes per day? \_\_\_\_\_ What type?  
\_\_\_\_\_

Q7) Do you take alcohol? Yes \_\_\_\_ No \_\_\_\_ If yes, how much per day?  
What type? \_\_\_\_\_

HbA1c level .....

**Appendix 4: Food Frequency Questionnaire**

1. How often do you serve the following meals?

MEAL	ALWAYS	SOMETIMES	NEVER
Breakfast			
Lunch			
Supper			
Others (Snacks)			

2. How often do you consume the following foods in a month?

Use the following response categories to indicate frequency of consumption of the foods indicated in the table below.

<b>1</b> = Never	<b>6</b> = 5-6 times/week
<b>2</b> = once/month or less	<b>7</b> = Once per day
<b>3</b> = 2-3 times/month	<b>8</b> = 2-3 times/day
<b>4</b> = Once/week	<b>9</b> = 4-6 times/day
<b>5</b> = 2-4 times/week	<b>10</b> = Over 6 times a day.

FOOD GROUPS	TYPE EATEN	FREQUENCY	FOOD COMPOSITION	NUTRIENTS INGESTED
Traditional Green Leafy Vegetables				
Exotic vegetables				
Insects				
Fruits				
Meat/Flesh				
Sea/lake food				
Offals/Matumbo				
Nuts and Seeds				
Tubers				
Sorghum				
Millet				
Maize				

<b>Flour (sifted)</b>				
<b>Flour (unsifted)</b>				
<b>Flour (fortified)</b>				
<b>Wheat</b>				
<b>Milk</b>				
<b>Eggs</b>				
<b>Beverages</b>				
<b>Rocks (Geophagy)</b>				

**Appendix 5: Dietary assessment questionnaire**

<b>24-HOUR RECALL FORM</b>	<b>Protocol #:</b>
	<b>Investigator Name:</b>
	<b>Medical Record #:</b>
<b>Patient Name:</b>	<b>Interviewer:</b>
<b>Age:</b>	<b>District:</b>
<b>Time:</b>	
<b>Date dd/mm/yy:</b>	

Indicate in the spaces below the types of food described by the interviewee as having been consumed over the last 24 hours. Note the ingredients used in the preparation of the dish and the method of preparation. Indicate the amount of the dish/product/food item consumed by the interviewee, based on appropriate household measures such as cups or other appropriate containers such as those for cooking fat, a noted size.

<b>Meal</b>	<b>Time &amp; place eaten</b>	<b>DISH (Food or drink description)</b>	<b>Ingredients</b>	<b>Preparation method</b>	<b>Serving amount (g or ml)</b>	<b>Food code</b>	<b>Amount code</b>
<b>Breakfast</b>							
<b>Snack</b>							
<b>Lunch</b>							
<b>Snack</b>							
<b>Supper</b>							
<b>Snack</b>							

## Appendix 6: International Physical Activity Questionnaire

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

\_\_\_\_\_ **days per week**

No vigorous physical activities → *Skip to question 3*

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

\_\_\_\_\_ **days per week**

No moderate physical activities



*Skip to question 5*

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

\_\_\_\_\_ **days per week**

No walking → *Skip to question 7*

6. How much time did you usually spend **walking** on one of those days?

\_\_\_\_\_ hours per day

\_\_\_\_\_ minutes per day

Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

\_\_\_\_\_ hours per day

\_\_\_\_\_ minutes per day

Don't know/Not sure

## Appendix 7: General knowledge on Diabetes and Physical Activity

### Instructions

Please **circle** the selection which you feel best, represents your feelings about diabetes and exercise as stated by the statements in the table below

	1	2	3	4	5
	Strongly disagree	disagree	neither dis/agree	agree	strongly agree
1	One should carry some food, sweets or glucose when exercising just in case the blood glucose falls too low				1 2 3 4 5
2	The type of food one eats may not affect the outcome of blood sugar levels during exercise				1 2 3 4 5
3	I don't think exercise is necessary so long as one can successfully control diabetes through diet control and medication				1 2 3 4 5
4	If one is on insulin they should avoid exercise soon after injecting insulin and should exercise after meals not before				1 2 3 4 5
5	Exercise is good for the diabetics as it helps control weight, lower blood sugar levels and reduce stress and tension				1 2 3 4 5
6	Exercise can help one to reduce or eliminate the need for medication by lowering blood sugar				1 2 3 4 5
7	It is important to talk to the doctor about the right exercise for me and on how to regulate medication before starting on an exercise program				1 2 3 4 5
8	One should check blood sugar levels before and after exercising				1 2 3 4 5
10	When my blood glucose is too high or too low, I should exercise to bring it back to normal				1 2 3 4 5
11	When my blood glucose is too high or too low I should NOT exercise				1 2 3 4 5
12	Exercises that cause us to increase our breathing rate and sweating should be avoided				1 2 3 4 5
13	Exercises that involve lifting heavy weights are good for diabetics				1 2 3 4 5
14	It is highly likely that a diabetic can develop complications like high blood pressure, heart, eye and foot problems from engaging in exercise				1 2 3 4 5
15	No exercise should be done at all by people who have complications such as blood pressure, heart, nerve, kidney or eye problems				1 2 3 4 5
16	It is safer for One NOT to eat or drink during exercise				1 2 3 4 5
17	One should drink plenty of fluids before during and after exercise				1 2 3 4 5
18	A diabetic should exercise for one and a half hours once per week as opposed to 30mins everyday				1 2 3 4 5
20	Diabetics don't have to wear an ID tag if they are exercising with people who know their condition and how to respond to a diabetic reaction				1 2 3 4 5
21	More information about exercise for the diabetic should be given to patients by the health care team				1 2 3 4 5

**Appendix 8: Clinical Examination**

Temperature \_\_\_\_\_ °C      Height \_\_\_\_\_ cm      Weight \_\_\_\_\_ Kg

General Condition \_\_\_\_\_

Peripheral sensation

**Cardiovascular system:**      Heart rate \_\_\_\_\_ Beats per minute

Blood Pressure \_\_\_\_\_ mmHg

Findings

Respiratory \_\_\_\_\_ system:

Abdomen:

**Appendix 9: Anthropometric Measurements**

Participants Name			
Participant ID			
District		Division	
Location		Village	
Age:	Sex:	D.O.B	
Examiner		Date of Exam	
Comment:			

	Trial 1	Trial 2	Mean
Height (cm)			
Weight (Kg)			
MUAC (cm)			

	Trial 1	Trial 2	Mean
Waist Circumference (cm)			
Hip Circumference (cm)			
Triceps Skin Fold (mm)			

## Appendix 10: Ethical Approval Letter



## KENYA MEDICAL RESEARCH INSTITUTE

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KEMRI/RES/7/3/1

FEBRUARY 08, 2008

**FROM:** SECRETARY, KEMRI/NATIONAL ETHICAL REVIEW COMMITTEE

**TO:** Mr. Festus Kaino Kiplamai (Principal Investigator)  
 Kenyatta University

**RE:** Seasonal variation in physical activity and dietary intake as it affects type II diabetes among the people living around the Lake Victoria

Dear Sir,

We acknowledge receipt of the revised informed consent document and questionnaire. The aim of the study is to determine the risk factors for developing and progression T2D in Africa as they appear to be different from those seen in developing countries. The results of this study will be of great social value as there has been a marked increase of this disease in Africa in recent years.

Due consideration has been given to ethical issues and the study is granted approval from today 8<sup>th</sup> February 2008 to 7<sup>th</sup> February 2009.

Please note that any changes to the research study must be reported to the Scientific Steering Committee and to the Ethical Review Committee prior to implementation. This includes changes to research design, equipment, personnel, funding or procedures that could introduce new or more than minimum risk to research participants.

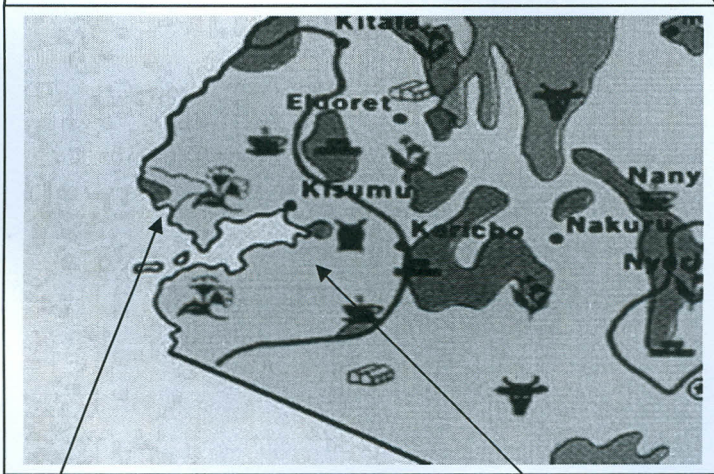
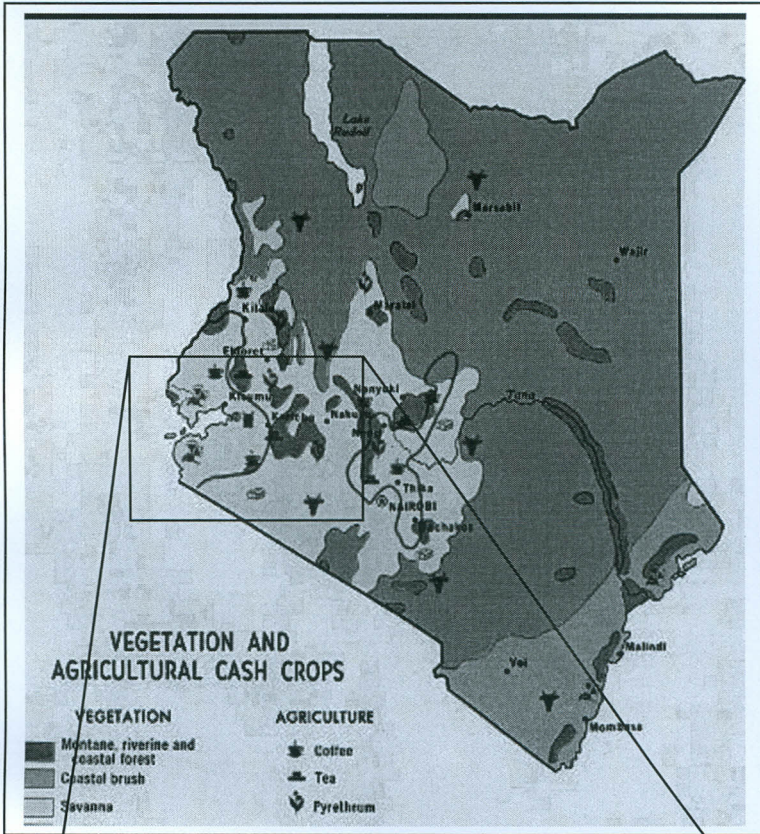
Respectfully,

R. C. Ethinji,

For: Secretary,

**KEMRI/NATIONAL ETHICAL REVIEW COMMITTEE**

Appendix 11: Map of Kenya showing research areas



Bondo Study site (Luo Community)

Kericho Study site (Kipsigis Community)