Lipid Profile in Sudanese Diabetic Patients

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April, 2011
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Date of Examination: 11/4/2011
DEDICATION

To my lovely parents: My father for his unconditional support for my study.

My mother for all helps for her good control of diabetes.

I would like to thank them both for giving me a chance to prove and improve myself through all my steps of my life.

To my sister Lubna for her all helps hopping her all dreams to become true.

To my brother Abdelmonim for his continuous support and advice.

To my friends for their supports during my study.

To all of them I dedicate this work with real love and respect.
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All thanks and praises be to Allah, the lord of the mankind and all existing creatures. So the prayers and peace be up on mercy prophet Mohammed.
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I express my deep thanks to all my colleagues and friends for their help, encouragement and support and for all the joyful moments we have had during this time.
I am most grateful to my family, my father, my mother my brother and special thanks to my sister for her continuous support, and for being on my side throughout the research.
Last but not least my appreciation and thanks to everyone who helped me in different ways during the study period.
ABSTRACT

This study composes of two parts, the first one is an experiment to evaluate the level of blood glucose and lipid profile (TC, TG, LDL, HDL and VLDL) among diabetic patients and comparison of the result with non diabetic subjects and the second one is a survey to assess the standards of healthcare and patients knowledge.

The subjects were divided into two groups according to insulin requirement. Type 1 is insulin dependent diabetes mellitus and Type 2 is non insulin-dependent diabetes mellitus and then divided according to gender (males and female) subgroups.

The study subjects selected for this study consist of one hundred Sudanese diabetic patients from Ribat university hospital during January 2009 they had mean age (52±11.063) years, a mean height (165.82 ±8.573) cm and a mean weight of (70.20±11.203) Kg. Fifty healthy non – diabetic subjects were chosen as controls, their mean age (45.72±11.169) years, mean height (167.28±9.450) cm and mean weight (71.02±13.429) Kg. Blood glucose and lipid profile total cholesterol (TC), Triglycerides (TG), Low-density lipoprotein (LDL) and High-density lipoprotein (HDL) were measured by enzymatic colorimetric methods in both groups, and very low density lipoprotein cholesterol were calculated for each sample.

All patients were interviewed and filled out the questionnaire consisted of five parts.

The result of the study found highly significant elevated level of blood glucose level among diabetic patients compared to non diabetic subjects. In addition to significant elevated level of serum lipids TC p=0.001, TG p=0.001, LDL p=0.001, and VLDL p=0.001. And decrease in HDL p= 0.001 level in diabetic patient compared to non diabetic subjects.

Among subgroups (type1, type2) diabetic patients glucose level and serum total cholesterol, triglycerides, LDL cholesterol and VLDL cholesterol were significantly higher (p<0.5) while HDL cholesterol was significantly lower when compared to non-diabetic subjects.

No statistically variation was found in the level of glucose and lipid between males and females diabetic patients.
A statistically positive correlation was found between blood glucose level and cholesterol ($r=0.02$), triglyceride ($r=0.052$), LDL-C ($r=0.023$) and VLDL-C ($r=0.056$). Negative correlation between glucose and HDL-C ($r=0.028$). Positive correlations were found between plasma glucose, and serum cholesterol, triglyceride, LDL-C, VLDL-C and duration of diabetes. ($r=0.070$), ($r=0.023$), ($r=0.009$), ($r=0.0075$), ($r=0.009$) respectively. Negative correlation between HDL-C and duration of diabetes ($r=0.12$).

The study indicated that standards of healthcare that many patients are unaware of the symptoms of diabetic complications and the effect of diabetes on kidneys, heart diseases, in addition decreased sexual performance in men (82%) than women (4%).

The study conclude that higher level of cholesterol, triglyceride, LDL-cholesterol and VLDL-cholesterol in diabetic patient compared to non-diabetic subjects with lower level of serum HDL–cholesterol in diabetic patient compared to non-diabetic subjects.

The majority of diabetic patients are unaware of their health states. Male diabetic patients should be screened for sexual performance to avoid impotence.
الخلاصة

هدفت هذه الدراسة إلى معرفة العلاقة بين تركيز الجلوكوز في الدم ومستوى تركيز الدهون عند مرضى السكري. كما هدفت إلى تقييم معايير الرعاية الصحية عند المرضى وممارساتهم ومعرفة تأثير السكري على الاداء الجنسي لديهم.

في هذه الدراسة تم الحصول على عينات دم من مائة فرد من الرجال والنساء تراوحت أعمارهم بين (23-80) عاماً مصابين بداء السكري بتنوعه الأول (داء السكري المعتمد على الإنسولين) والثاني (داء السكري غير المعتمد على الإنسولين). كما تم الحصول على عينات دم من خمسين فردًا أصحاء غير مصابين بداء السكري كمجموعة تحكم للمقارنة.

تم قياس الجلوكوز والدهون في الدم (TC,TG,HDLDLDL) بواسطة قياس الطيف الضوئي كما تم حساب (VLDL). وتم إجراء لقاءات شخصية مع المرضى لمعرفة معايير الرعاية الصحية لديهم. أظهرت نتائج الدراسة أن هناك ارتفاع واضح في (TC,TG,LDL,VLDL) كما وجد انخفاض في مستوى (HDL) عند مرضى السكري مقارنة بمجموعة التحكم أجريت أيضاً مقارنة بين مرضى السكري من النوع الأول ومرضى السكري من النوع الثاني ومجموعة التحكم. أظهرت نتائج مماثلة في معدل اذداد (TC,TG,LDL,VLDL) وانخفاض (HDL) بينما لم توجد أي فروق إحصائية عند دراسة تأثير النوع على مستوى الدهون في الدم بين مرضى السكري.

أظهرت الدراسة وجود علاقة طردية ما بين مستوى تركيز الجلوكوز في الدم والدهون (HDL) ووجود علاقة عكسية ما بين مستوى تركيز الجلوكوز لدى مرضى السكري مقارنة بمجموعة التحكم.

كما أظهرت الدراسة وجود علاقة طردية ما بين مستوى تركيز الجلوكوز في الدم والدهون (HDL) وفترة الإصابة بداء السكري وجود علاقة عكسية ما بين (TC,TG,LDL,VLDL) وفترة الإصابة بداء السكري لهؤلاء المرضى. أظهرت دراسة معايير الرعاية الصحية أن كثير من المرضى يجهلون اعراض مضاعفات السكري وتأثير السكري على كل من الكلى والقلب ولهو انخفاض معدل الاداء الجنسي عند الرجال (82%) أكثر من النساء (4%).
توصلت الدراسة إلى أن هناك ضرورة لعمل فحص دوري للدهون لتأثيرها المباشر على أمراض القلب والشرايين عند مرضى السكري كذلك فحص الوظائف الكلى وفحص دوري قاع العين علاوة على تثقيف المرضي عن المرض وعلى الآثار المترتبة عليه جراء عدم المحافظة على مستوى تركيز الجلوكوز في الم معدل المسوق به.

إضافة إلى ضرورة معالجة اضطرابات الأداء الجنسي خاصة من ناحية ضعف الانتصاب ورنين الرغبة في ممارسة الجنس.
TABLE OF CONTENTS

DEDICATION .............................................................................................................................. I
ACKNOWLEDGEMENT ............................................................................................................II
ABSTRACT ............................................................................................................................ III
ARABIC ABSTRACT ............................................................................................................ V
TABLE OF CONTENTS ........................................................................................................... VII
LIST OF TABLES ................................................................................................................ X
LIST OF FIGURES .............................................................................................................. XI
ABBREVIATIONS ............................................................................................................... XII
CHAPTER ONE ..................................................................................................................... 1
LITERATURE REVIEW ......................................................................................................... 1
  1.1. Introduction: .................................................................................................................. 1
  Objectives: .......................................................................................................................... 3
  1.1.1. Diabetes Mellitus .................................................................................................... 4
  1.1.2. Classification of Diabetes Mellitus: ........................................................................ 5
    1.1.2.1. Insulin-Dependent Diabetes Mellitus (IDDM): ................................................... 5
    1.1.2.2. Non-Insulin Dependent Diabetes Mellitus (NIDDM): ....................................... 6
    1.1.2.3. Gestational Diabetes Mellitus: ......................................................................... 6
    1.1.2.4. Other Specific Types of Diabetes Mellitus: ....................................................... 7
  1.1.3 Diagnosis of Diabetes Mellitus: .............................................................................. 8
  1.1.4. Diabetes Mellitus in Sudan: .................................................................................. 9
  1.1.5. Diabetes Mellitus and Etiology: .......................................................................... 11
    1.1.5.1. Diabetes Mellitus and Physical Activity: ......................................................... 11
    1.1.5.2. Diabetes Mellitus and Dietary Factor: ............................................................. 12
    1.1.5.3. Diabetes Mellitus and Obesity: ...................................................................... 13
    1.1.5.4. Diabetes Mellitus and Smoking: ................................................................... 15
  1.1.6. Diabetes Mellitus and Carbohydrates: ................................................................. 16
    1.1.6.1. Insulin Hormone: ............................................................................................. 17
    1.1.6.2. Hyperglycemia: ............................................................................................... 19
    1.1.6.3. Hypoglycemia: ............................................................................................... 20
  1.2. Normal lipids Metabolism: ...................................................................................... 20

VII
LIST OF TABLES

Table 3.1: Essential Physical Data of Diabetic Patients and Control Subjects (Mean ± SD). .................................................................................................................................................39

Table 3.2: Levels of Glucose and Serum Lipid Profile in Diabetic Patients and Control Subjects. .................................................................................................................................................40

Table 3.3: Levels of Glucose and Lipid Profile in Males and Females Diabetic Patients. .................................................................................................................................................42
LIST OF FIGURES

Figure 3.1: Mean Values of Glucose and Lipid (TC, TG, LDL, HDL, VLDL mg/dl) of Type 1 and Type 2 Diabetic Patients and Non-Diabetic Subjects.........................41
Figure 3.2: Percentage of Diabetes Duration (years)........................................43
Figure 3.3: Percentage of Diabetic Patients Did Not Practice Exercises (Low Physical Activity)...........................................................................................................44
Figure 3.4: Percentage of Diabetic Patients They Were Observed Decrease in Sex Rate by Gender............................................................................................................44
Figure 3.5: Correlation Between Glucose Level and Cholesterol .........................46
Figure 3.6: Correlation Between Triglyceride Level and HDL-Cholesterol...........47
## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>4- AA</td>
<td>4- AminoAntipyrine</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>CE</td>
<td>Cholesterol Esterase</td>
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<td>CHD</td>
<td>Coronary Heart Disease</td>
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<td>CO</td>
<td>Cholesterol Oxidase</td>
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<td>DM</td>
<td>Diabetes Mellitus</td>
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<tr>
<td>DHAP</td>
<td>Di Hydroxy Acetone Phosphate</td>
</tr>
<tr>
<td>FBG</td>
<td>Fasting Blood Glucose</td>
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<tr>
<td>FFA</td>
<td>Free Fatty Acids</td>
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<tr>
<td>FPG</td>
<td>Fasting Plasma Glucose</td>
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<tr>
<td>FSD</td>
<td>Female Sexual Dysfunction</td>
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<td>G-3-P</td>
<td>Glucose -3 phosphate</td>
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<td>GDM</td>
<td>Gestational Diabetes Mellitus.</td>
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<td>GK</td>
<td>Glycerol kinase</td>
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<td>GOD</td>
<td>Glucose Oxidase Dehydrogenises</td>
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<tr>
<td>GPO</td>
<td>Glycerol Phosphate Oxidase</td>
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<td>HDL-C</td>
<td>High Density Lipoproteins Cholesterol</td>
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<td>IDDM</td>
<td>Insulin Dependent Diabetes Mellitus</td>
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<tr>
<td>IGT</td>
<td>Impaired Glucose Tolerance</td>
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<tr>
<td>IRAS</td>
<td>Insulin Resistance Atherosclerosis Study</td>
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<tr>
<td>LDL-C</td>
<td>Low density lipoproteins cholesterol</td>
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<tr>
<td>LDL-C</td>
<td>Very Low Density Lipoproteins Cholesterol</td>
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<tr>
<td>LPL</td>
<td>LipoProtein Lipase</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>MI</td>
<td>Myocardial Infarction</td>
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<tr>
<td>MRDM</td>
<td>Malnutrition-Related Diabetes Mellitus</td>
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<tr>
<td>NCEP</td>
<td>National Cholesterol Education Program</td>
</tr>
<tr>
<td>NIDDM</td>
<td>Non-Insulin Dependent Diabetes Mellitus</td>
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<tr>
<td>OGTT</td>
<td>Oral Glucose Tolerance Test</td>
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<tr>
<td>PA</td>
<td>Physical Activity</td>
</tr>
<tr>
<td>PG</td>
<td>Plasma Glucose</td>
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<tr>
<td>POD</td>
<td>Peroxidase Oxidase Dehydrogenase</td>
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<tr>
<td>TC</td>
<td>Total Cholesterol</td>
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<tr>
<td>TG</td>
<td>Triglycerides</td>
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CHAPTER ONE
LITERATURE REVIEW

1.1. Introduction:

Diabetes mellitus (DM) defined as a metabolic disorder of multiple etiology, characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both (Scoppola et al., 2001; WHO., 1994). Chronic hyperglycemia is associated with the long-term consequences of diabetes that include damage and dysfunction of the cardiovascular system, eyes, kidneys and nerves. The complications of diabetes are often divided into two groups: microvascular (retinopathy, nephropathy, and neuropathy) and macrovascular (ischaemic heart disease, stroke, peripheral vascular disease). These estimates relate to the direct burden of diabetes as a proximate cause and do not include the attributable burden of diabetes to renal failure and cardiovascular disease.

DM classified either the absence of insulin that is Insulin-Dependent Diabetes Mellitus IDDM or type1 or which is insensitive to the insulin that is Non-Insulin Dependent Diabetes Mellitus NIDDM or type2 the most common form is effecting ever younger age groups striking young adults and even adolescents (Wild et al., 2004).

Most of the studies agreed that diabetes mellitus is an epidemic diseases in most countries it has become almost universal killer, it was announced that sugar has become the fourth largest diseases leading to death in the world, World Health Organization (WHO) estimated that the number of people with diabetes worldwide in year 2000 was 177 million, this increase to at least 336 million by the year 2030, with prevalence around 5.4% to major concern are that much of this increase will be in the developing countries (approximately 75% of all persons) (WHO.,1999; DM Guideline 2008).

DM in Sudan is a rapidly growing public health problem, in a population-based survey (1992) the prevalence rate of DM and IGT were 3.4% and 2.9% respectively in adulates population in northern states. The highest prevalence in the northern part (5.5%) and the lowest in the western desert-like part (0.9%).The highest prevalence is demonstrated in Danagla tribe (8.3%). Statistical report showed that the number of
inpatient was more than doubled in 5 years time (1999-2003), half of them being in Khartoum state. In 2002 DM was the ninth case of admission in Sudan.

In Khartoum state stepwise survey was done in 2006, the prevalence of DM in adults was 19.2%. The prevalence is increased largely due to population growth, aging, urbanization, sedentary life style and food consumption pattern with high fat contents and more refined carbohydrates, at least 50% of all people with diabetes are unaware of their healthcare.

DM is chronic illness that requires continuous medical care and educating patients on self management to achieve normal or near normal blood glucose levels in patients with diabetes and this will prevent acute complications and reduce the risk of long term complications (Guideline of DM 2008).

DM include damage and dysfunctions for many organs and systems lipid abnormalities one of the diabetes dysfunctions, it commonly occurs in type 2, so that analysis of serum lipids has become an important health management, (American Diabetes Association) reported that lipid profile test to determine levels of serum total cholesterol, triglycerides, HDL cholesterol (HDL-C), and LDL cholesterol (LDL-C). Nevertheless, lipid testing rates among individuals with diabetes have been far less than ideal (A.D.A), and can be broadly categorized into two groups: those that are common to the general population, for example elevated total and LDL cholesterol and additional diabetes related abnormalities for example elevated triglycerides and reduced HDL cholesterol (Cowie et al., 1994; Siegel et al., 1996).

The prevalence of sex dysfunction in diabetes mellitus population in Sudan has not sufficient attention yet. Currently no data reported on the relation between diabetes mellitus and sex dysfunction. But international study showed that diabetes has long been considered a major cause of impaired sexual function. Diabetic men have substantially increased risk of erectile dysfunction (ED), it defined as a consistent inability to have an erection firm enough for sexual intercourse (Brown et al., 2005).

Although sexual dysfunction in women with diabetes have lagged behind those in men, likely due to several factors, including a lack of standardized definitions of sexual dysfunction in women, absence of well-validated scales, and societal taboos regarding female sexuality (Rosen et al., 2005).
Objectives:

• General objectives:
  1- To evaluate serum lipids in Sudanese diabetic patients.
  2- To investigate sex dysfunctions in Sudanese diabetic patients.

• Specific objectives:
  1- To measure serum level of total cholesterol, triglycerides, low density and high density lipoprotein in Sudanese diabetic patients.
  2- To assess the lipid profile among Sudanese diabetic patients with respect to disease duration and also with gender.
  3- To assess healthcare standards and patients knowledge of the Sudanese diabetic patients.
1.1.1. Diabetes Mellitus

Diabetes mellitus (DM) is a multi-factorial disease which is characterized by hyperglycemia, (elevation of blood glucose level caused by a relative or absolute deficiency in insulin) lipoprotein abnormalities and oxidative stress (Scoppola et al., 2001; wild et al., 2004). Chronic hyperglycemia is associated with the long–term consequences of diabetes that include damage and dysfunction of the cardiovascular system, eyes, kidney and nerves (wild et al., 2004). Diabetes mellitus is characterized by polyuria, polydipsia and weight loss in spite of polyphagia, hyperglycemia, glycosuria, ketosis, acidosis and coma. Furthermore feeling tired or ill, feeling irritable, urinating more than normal, being very thirsty, being very hungry, unexplained weight loss, blurred vision, fever, headache, and dry itchy skin may include symptoms of diabetes (Young et al., 2000). There are wide spread biochemical abnormalities but the fundamental defects to which most of the abnormalities can be traced are reduced entry of glucose into various peripheral tissues and increased liberation of into the circulation from the liver. There is therefore an extra cellular glucose excess and in many cells, an intracellular glucose deficiency, there is also decrease in entry of amino acid into muscle and an increase in lipolysis (Ganong., 2003).

Diabetic patients are at high risk for dyslipidemia, cardiovascular disease (CVD) and mortality (Harris., 1998). Dietary modification and lipid lowering medication can reduces serum lipid levels and lower the occurrence of (CDV) events (Jonsson et al., 1999).

In diabetic patients lipid profile is characterized by an elevation in both postprandial and fasting plasma triglyceride (TG) and low level of HDL cholesterol (De Man et al., 1996; Barrett-Connor and Wingerd., 1983). Therefore in fact diabetes mellitus is characterized not only by alteration in glucose insulin axis but marked features described as the diabetic dyslipidemia (Kreisberg., 1998). The increased lipid level and total cholesterol synthesis during hyperglycemia may contribute to the acceleration of atherosis in diabetes mellitus (Bennion and Grundy., 1977). Lipid profile, which is altered in diabetes state (Betteridge., 1994), is one of the significant factors in development of cardiovascular diseases studies have shown that increased plasma triglyceride and cholesterol levels may be a risk factor for vascular disease (Kamata and Yamashita.,1999; Kamata et al., 2001; Shahar et al., 2003).
Also oxidative modification of LDL is an important step in the development of atherosclerosis (Felmeden et al., 2003). The prevalence of type2 DM is increasing at dramatic rate, and the economic costs of caring for patients with diabetic complications are high, this increase is closely associated with the epidemic of obesity in industrialized countries. Reduced physical activity is a contributing factor as sedentary lifestyles become more common. Increased body fat, particularly in the visceral compartment, is a strong risk factor for the development of type2. Elucidation of such risk factors will lead to interventions that can delay the onset or protect against the development of type2 DM.

1.1.2. Classification of Diabetes Mellitus:

The World Health Organization has described diabetes under the clinical classes of DM and impaired glucose tolerance (IGT). The major classes of DM include:

- Insulin Dependent Diabetes Mellitus (IDDM), known as type1 DM.
- Non-Insulin Dependent Diabetes Mellitus (NIDDM), known as type2 DM.

Persons with IDDM require insulin treatment for survival, due to pancreatic islet β-cell destruction and are prone to ketoacidosis.

Non-Insulin Dependent Diabetes Mellitus can progress to the state of requiring insulin treatment, but this progression is not necessarily related to β-cell destruction but rather to deficiency in insulin production or a condition of insulin resistance (a decreased biological response to insulin) (Taylor et al., 1994).

- Gestational Diabetes Mellitus (GDM).
- Other types of diabetes mellitus associated with specific conditions.

1.1.2.1. Insulin Dependent Diabetes Mellitus (IDDM):  

The onset of IDDM or type1 diabetes is most common in children or young adults and accounts for around 10% or less of the total number of people with diabetes (WHO., 1999). Type1 indicates the processes of β-cells destruction that may ultimately lead to diabetes mellitus in which insulin is required for survival to prevent the development of ketoacidosis (acidosis due to an excess of ketone bodies, which accumulate due to the incomplete metabolism of fatty acids), coma and death. An individual with a type1 process may be metabolically normal before the disease is clinically manifest, but the process of β-cells destruction can be detected. Type1 is usually characterized by the presence of anti-glutamic acid decarboxylase (anti-GAD) antibodies, islet cell or insulin antibodies which identify the autoimmune processes that lead to β-cells
destruction. In some subjects with this clinical form of diabetes, particularly non
caucasians, no evidence of an autoimmune disorder is demonstrable and these are
classified idiopathic type1. Etiological classification may be possible in some
circumstances and not in others. Thus, the category of type1 diabetes can be identified
if appropriate antibody determinations are performed (WHO., 2003).

1.1.2.2. Non -Insulin Dependent Diabetes Mellitus (NIDDM):
The second type of diabetes mellitus is (NIDDM) or type2 is more complex in
etiology and characterized by a relative insulin deficiency reduce insulin action and
insulin resistance of glucose transport in skeletal muscle and adipose tissue.
It develops gradually without obvious symptoms and the progression to full diabetes
ensues when pancreatic β-cells hypersecretion of insulin fails to compensate for
insulin resistance (Polonsky et al., 1996). Type2 DM usually diagnosed by tests that
indicate glucose intolerance, it is linked with behavior (life style), environment and
social factor such as over weigh and unhealthy dietary habits and obesity. Patients
with type2 DM have two fourfold increase in cardiovascular disease (CVD) and
dramatically higher risk of accelerated cerebral and peripheral vascular disease (King
et al., 1993; Brown., 2000). The metabolic alternation observed in NIDDM are milder
than those described for the insulin-dependent diabetes mellitus form of the disease,
and are thought to be due to a combination of two factors dysfunctional β-cells and
insulin resistance. The incidence and prevalence of type2 diabetes mellitus are rapidly
increasing worldwide in both developing and developed nations (Amos et al., 1997).

1.1.2.3. Gestational Diabetes Mellitus:
Gestational diabetes is a state of carbohydrate intolerance resulting in hyperglycemia
of variable severity, with onset or first recognition during pregnancy. It does not
exclude the possibility that the glucose intolerance may antedate pregnancy but has
previously gone unrecognized. The definition applies irrespective of whether or not
insulin is used for treatment or whether the condition persists after pregnancy.
Women who are known to have diabetes mellitus and who subsequently become
pregnant do not have gestational diabetes but have (diabetes mellitus and pregnancy)
and should be treated accordingly before, during and after the pregnancy (WHO.,
1999). In the early part of pregnancy fasting and postprandial glucose concentrations
are normally lower than in normal, non-pregnant women. Elevated fasting or
postprandial plasma glucose levels may well reflect the presence of diabetes that
antedates pregnancy, but criteria for designating abnormally high glucose concentration at this time in pregnancy have not yet been established. The occurrence of higher than usual plasma glucose levels at this time in pregnancy mandates careful management and may be an indication for carrying out an OGTT. Nevertheless, normal glucose tolerance in the early part of pregnancy does not itself establish that gestational diabetes will not develop later. Individuals at high risk for gestational diabetes include older women, obese, women those with previous history of glucose intolerance, any pregnant woman who has elevated fasting or casual blood glucose levels those with a history of gestational diabetes mellitus those with a history of large for gestational age babies, women from certain high risk ethnic groups and strong family history of diabetes mellitus. It may be appropriate to screen pregnant women belonging to high risk population groups during the first trimester of pregnancy in order to detect previously undiagnosed diabetes mellitus. Women at high risk who screen negatively and average risk women should be tested between 24 and 28 weeks of gestation (WHO 1999; WHO., 1994).

1.1.2.4. Other Specific Types of Diabetes Mellitus:

Other specific types are currently less common causes of diabetes mellitus, but are conditions in which the underlying defect or disease process can be identified in a relatively specific manner they include:

- Sub classed as obese or non obese DM and they are associated conditions and syndromes. Patients with IDDM and NIDDM are most commonly seen in physical therapy because of the microvascular and macrovascular complications of the disease. They will therefore be discussed in greater detail.
- Genetic defects in β-cells, such as maturity onset diabetes of the young.
- Genetic defects in insulin action, such as Leprechaunism.
- Diseases of the exocrine pancreas, such as cancer of the pancreas, cystic fibrosis and fibrocalculous pancreatopathy (a form of diabetes, which was formerly classified as one type of malnutrition related diabetes mellitus).
- Endocrinopathies, such as cushing syndrome, acromegaly and phaeochromocytoma.
- Drugs or chemicals, such as steroids and thiazides.
- Uncommon forms of immune related diabetes, such as the type associated with insulin receptor antibodies.
• Other rare genetic syndromes associated with diabetes, such as Klinefelter syndrome and Down syndrome (WHO., 1999).

• Malnutrition related diabetes mellitus (MRDM) is associated with nutritional deficiency and is seen in tropical developing countries (William and Pickup., 1992).

1.1.3 Diagnosis of Diabetes Mellitus:
Diabetes is a silent disease so the diagnosis of it in an asymptomatic individual should never be made on the basis of a single abnormal glucose value, verification of the diagnosis with repeat testing is required, unless an individual presents with unequivocal hyperglycemia long with its classic symptoms. Diabetes often has no symptoms or warning signs. The only way to be sure is to have your blood tested for glucose (blood sugar). Many other metabolic abnormalities occur notably an increase in ketone bodies in the blood when there is severe lack of insulin (Abdelgader., 2006). The most recent World Health Organization diagnosis diabetes mellitus is a fasting blood glucose $\geq 7.0 \text{ mmol/l (126 mg/dl)}$ or plasma glucose concentration $\geq 11.1 \text{ mmol/l (200 mg/dl)}$ are clearly diagnostic of diabetes (WHO., 2003). Glycosuria usually occurs when blood glucose values are greater than 180 mg/dl but this threshold varies considerably between individuals and increase with age. For reliable result a glucose tolerance test should be performed in morning after an overnight fast with the patient sitting quietly. It is also important that he should have had normal meal for the last three days and should not have been dieting. False results may also occur if the patient has been ill recently or has had prolonged bed rest. Blood glucose concentration are measured fasting and then every half an hour (For two hours) after drink of 75 g of glucose in 250-350 ml water (in children 1-75 g/kg to a maximum of 75 g), urine tests should be performed before the glucose drink and at one and two hours. (The oral glucose tolerance test (OGTT) (Tietz et al., 2000; Peter., 1982).

In diabetes, glucose piles up in the bloodstream, especially after meals. If glucose load is given to a diabetic, the plasma glucose rises higher and returns to the base line more slowly than it does in normal individuals. The response to a standard oral test dose of glucose, the oral glucose tolerance test, is used in the clinical diagnosis of diabetes.
Impaired glucose tolerance in diabetes is due in part to reduced entry of glucose into cells (decreased peripheral utilization) in the absence of insulin, the entry of glucose into skeletal, cardiac, and smooth muscle and other tissues is decreased (Ganong, 2003).

1.1.4. Diabetes Mellitus in Sudan:

Diabetes mellitus is the major health problem in this country because Sudan has had contact with middle-East Mediterranean civilization since ancient times. The western part has many contacts with West Africa and the Eastern part have maintained close links of country undergone ethnic absorption of immigrant Arabs during times of Islamizing and culturally became arabised. About 70% of Sudanese population lives in the northern part of country, 20% of populations are urban settlers and 10% of the rural inhabitants are nomads. Regular internal migration in different part of Sudan has taken place from rural areas and small towns to big cities, particularly to the capital, Khartoum. This has been compounded by displacement of large proportion of population from drought and famine prone areas in western and southern region. In recent years permanent external migration has also occurred (Elbagir, 1995). These cultural changes have lead to considerable progress in educational and health establishment as well improvement in the standards of living. These social and economic advances were accompanied by change to modern life style characterized by higher caloric intake and less physical activity and the emergence of non communicable diseases such as diabetes mellitus a major health problem casing high morbidity and mortality. It can be estimated from the hospital record that the number of diabetic patients is increasing in all socioeconomic class. Type2 DM accounts for 75% of all diabetic patients attending the outpatient diabetic clinic in Khartoum (Elmhadi et al., 1989). In more recent study 95% of all diabetic patients attending diabetes clinic in the out central state were classified as having NIDDM however 75% were treated with insulin (Bani and Anokute, 1994).

In both studies, the classification of IDDM was based on early onset of diabetes (<15 years) and previous history of diabetic ketoacidosis.

Obesity was feature characterized 39–49% of all diabetic patients and strong association with family history of diabetes has been reported (Bani and Anokute, 1994; Elmhadi et al., 1989). In northern Sudan, a family history of diabetes was 2.3 times more often reported among diabetics than non-diabetics (Elbagir et al., 1996).
IDDM among children 7-14 years of age, is not rare in Sudan, and showed a steady rise in the incidence rate over 4-years period (Elamin et al., 1989; 1992). IDDM in the previous studies it was found that in Sudan, NIDDM is a common disease with sever clinical course and that most patient are poorly controlled and exhibit a high prevalence of acute and chronic complications (Elmahdi et al., 1991; 1989).

Elamin and his colleagues in Sudanese study they were reported 10% of children were not admitted at the time of diagnosis, being admitted only after they developed diabetic ketoacidosis (DKA) or hypoglycemia (Elamin et al., 1997). This situation contributes to omission of patients in the registry as well as to the possibility of death before diagnosis, especially for those aged <5 years.

Among children and adolescents, almost all these with diabetes were poorly controlled, and received a minimum of diabetes care. Both acute and long-term complications were common and associated with a high mortality rates among these children (Elamin et al., 1992). The poor metabolic control of Sudanese diabetic patients was attributed to the poor compliance and poor knowledge of diabetes and to problem associated with injection and drug availability (Elmahdi et al., 1991). The ability of patients with diabetes to understand and manger their diseases in ordinary daily life is a most important for successful therapy. Despite the above studies, there is still a paucity of information on diabetes in Sudan available knowledge has prompted us to conduct the current diabetes research, with the goal of contributing to the overall improvement of diabetes care in Sudan. A report shows that the prevalence of diabetes mellitus and impaired glucose tolerance in different parts of Sudan varies widely between different groups this variation due to environmental, nutritional and genetic factors. The overall crude prevalence rate of DM and impaired glucose tolerance in adult population in northern part of Sudan were 3.4% and 2.9% respectively. The highest overall prevalence was in northern part of Sudan 5.5% and the lowest in the western desert population 0.9%.

The high prevalence of undiagnosed diabetes will have a profound in community in general and in public health services in particular (Elbgir et al., 1996).

In Dangale community in northern state of Sudan has particularly higher prevalence of diabetes 8.3% while in a subgroup of this community, with Egyptian descent the prevalence was 10.8%. There were no urban /rural or male/female differences in prevalence (Elbagir et al., 1996).
1.1.5. Diabetes Mellitus and Etiology:

Worldwide prevalence of diabetes is alarmingly high because diabetes mellitus is an important cause of morbidity and a major risk factor for cardiovascular disease, specially the increasing prevalence of type 2 diabetes is associated with the aging population, a significant rise in the prevalence of a sedentary lifestyle (Hux and Tang., 2003). Body composition, obesity habitual physical activity (PA) levels, diet and smoking are factors that are at least partly etiology determined, and all are known to exert their own substantial and independent effects on insulin resistance and type 2 diabetes. Etiological factors clearly must play substantial role in determining type 2 diabetes prevalence, because type 2 diabetes has become dramatically more common in the last few decades. During this same time, factors such as habitual PA levels and body composition have changed substantially while negligible genetic alterations could have occurred over this time frame (Winfred et al., 2004).

Dietary intake is a potentially modifiable risk factor. Indeed 60 to 90% of type 2 diabetes cases appear to be related to obesity or weight gain and smoking (Anderson et al., 2003). In addition to moderate increases in physical activity and a weight loss of 5% of initial body weight can reduce the risk of developing type 2 diabetes by 58% (Anderson et al., 2003; Wing et al., 1987). As WHO reported life style plays important role in DM prevention because lifestyle changes aimed at weight control and increased physical activity are important objectives in the prevention of type 2 diabetes mellitus. The benefits of reducing body weight and increasing physical activity are not confined to type 2 diabetes they also play a role in reducing heart disease and high blood pressure. Lifestyle is the key to reversing these trends (WHO., 1997, 2001).

1.1.5.1. Diabetes Mellitus and Physical Activity:

WHO defined physical activity as any bodily movement produced by skeletal muscle that requires energy expenditure. Lack of physical activity is an independent risk factor for chronic diseases, and overall is estimated to cause 1.9 million deaths globally. Regular physical activity such as walking, cycling, or dancing has significant benefits for health. For instance it can reduce the risk of cardiovascular disease diabetes and osteoporosis help control weight and promote psychological well being. Everyone should engage in at least 30 minutes of moderate physical activity every day. More activity may be required for weight control (WHO., 2005).
Several clinical studies have shown that physical activity is effective in preventing diabetes and may reduce plasma insulin level with improved insulin sensitivity and glucose intolerance in type2 DM and normal subject (Devlin and Horton., 1985).

It has been shown that regular PA may be associated with 50-60% reduction in risk for type2 DM has been found to be independent of age, obesity, BMI, family history and gender (Dowse et al., 1991; Sherman et al., 1998). It was suggested that training and physical fitness protect against glucose intolerance, whereas profound inactivity leads to worsening of glucose tolerance (Schranz et al., 1991). The prevalence of glucose intolerance was found raise from 8% in highly active subject to 30% in moderately active and 62% in those with low activity levels. However, the effects of physical activity on the number of years lived with and without diabetes are still unclear. Whether, for example, higher levels of physical activity would reduce the number of years lived with diabetes depends on the balance of its effect on the risks of developing diabetes and mortality (Mamun et al., 2004).

1.1.5.2. Diabetes Mellitus and Dietary Factor:

Diet plays an important role in achieving and maintaining good glycolic control in diabetic patients. It has a role in preventing obesity and consequently type2 diabetes and may also reduce risk of type2 diabetes independent of changes in body weight. However it has been suggested that obesity may mediate the effects of dietary factors possibly through reduced physical activity. It has been shown that prior to onset diabetic subjects consumed diets with high energy and fat contents and an inverse relationship was found between prevalence of diabetes and consumption of fiber rich diet (Ringrose and Zimmet., 1979). In practice each nutrient or food is part of a larger pattern consisting of many nutrients and foods and thus characterization of multiple, concurrent a dietary exposure has particular relevance to health. There is associations between dietary patterns and type2 diabetes, many studies show that dietary patterns characterized by high whole grain fruit/vegetable and low fat dairy intake are inversely associated with type2 diabetes risk. Analogously dietary patterns characterized by high intake of red or processed meats; refined grains, fried foods and foods containing high amounts of added sugars are associated with greater type2 diabetes risk (Fung et al., 2002; Van Dam et al., 2002; Halton et al., 2006; Gittelsohn et al., 1998; Hodge et al., 2007).
Several studies in non diabetic subjects have indicated that a high intake of saturated fat (SAFA) is associated with increased risk of CHD, whereas high intakes of polyunsaturated fat (PUFA) and monounsaturated fat (MUFA) are associated with reduced risk. High intake of SAFA may induce insulin resistance and thus worsen glycolic control (Louheranta et al., 2000). Moreover a decrease in dietary SAFA intake and an increase in PUFA and MUFA intake favorably influences plasma lipid and lipoprotein concentrations, which are important predictors of CHD events in non diabetic and diabetic individuals (Schaefer., 2000; Grundy., 1991).

Lastly dietary intake is a potentially modifiable risk factor although there is convincing evidence for the role of excess calorie intake in the development of type2 diabetes, the evidence surrounding other diet related risk factors is far less complete or convincing (Steyn et al., 1998).

1.1.5.3. Diabetes Mellitus and Obesity:
The term obesity implies excess body fat yet accurate measurement of body composition is not widely available in the clinical setting. Therefore most clinical definition of obesity relies on measure of body weight adjusted for height such as body mass index (BMI in kg/m²). Clinical guidelines that define overweight as a BMI of 25–27 kg/m² and obesity as a BMI>30kg/m² these cutoffs are consistent with those used by the world health organization (WHO., 1995).

Obesity poses an emerging global health care problem and is considered a major risk factor in the development of diabetes and cardiovascular disease. Today more than 1.1 billion adults are overweight worldwide, and among them 312 million are considered to be obese. In addition the International Obesity Task Force estimates that at least 155 million children worldwide are overweight or obese. Over the past 20 years, obesity rates have tripled in developing countries that have been adopting a western lifestyle involving decreased physical activity and over consumption of cheap energy dense food. Such lifestyle changes are also affecting children in these countries, the prevalence of overweight among them ranges from 10 to 25% and the prevalence of obesity ranges from 2 to 10%. The Middle East Pacific Islands, Southeast Asia and China face the greatest threat.

Childhood obesity is the greatest challenge to child health in the 21st century. In 2006, the prevalence of obesity in children reached 17% in the United States.
If current trends remain unchanged, the prevalence of childhood obesity is expected to reach 20% by 2010 (Koplan, 2006). Although obesity in children is multifaceted, little doubt remains that the factors driving this phenomenon include rapid changes in the modern food and activity environment of children superimposed onto genetic and metabolic predispositions for weight gain (Lee et al., 2006). Current evidence suggests that insulin resistance may be both a cause and an effect of childhood obesity and may even be induced by prenatal factors (Jimenez-Chillaron et al., 2006; Kimbro et al., 2007). Race, poverty, geography and lower access to health care all of which add to increased risk of obesity for children affected by any of these variables (Block et al., 2004).

The child and family sit at the center of any effective prevention and treatment strategies and their actions will ultimately determine success or failure. Because behavior and lifestyle change is the first intervention, deciding who will and will not benefit from actions to prevent or treat obesity becomes the first objective in the health care environment, funding for weight loss treatment may be limited. This includes costs associated with healthcare encounters and expenses related to making different food choices, purchasing exercise equipment, and other costs associated with access to these resources. For healthcare providers, cost reimbursement for obesity prevention and care remains limited. For families, barriers to care access may be distance, work, or school related. For these reasons, it is most practical to incorporate as much of the assessment and intervention for obesity as possible into the health maintenance visit environment (Krebs and Jacobson, 2003).

The prevalence of obesity associated with large number of risk factor including hypertension, hypercholesterolemia, hypertriglyceridemia, increased low-density lipoprotein (LDL)-cholesterol increased very-low-density lipoprotein (VLDL)-cholesterol, Decrease high-density lipoprotein (HDL)-cholesterol, early atherosclerotic lesions (Winkleby et al., 1999).
1.1.5.4. Diabetes Mellitus and Smoking:

Increased mortality and disability in industrialized countries is related to smoking (Doll et al., 1994; Mokdad et al., 2004). It is estimated that globally, in the year 2000, 4.83 million people died prematurely because of smoking (Ezzati et al., 2003). Smoking rates vary greatly between different countries and different populations, the prevalence of smoking is highest in the South-East Asia and Western Pacific regions and lowest in the African and American regions (WHO, 2007). The WHO MONICA study including 37 populations from 21 countries (individuals aged 35-64 years) reported the prevalence of smoking has been decreasing in majority of male populations while it was increasing in most of the female populations (Evans et al., 2001).

Cigarette smoking is well established as a causal factor in coronary heart disease (CHD) and stroke. It is not a well documented risk factor for type2 diabetes, although diabetes and CHD have many common causal factors, a recent review of smoking and diabetes concluded that evidence that smoking is associated with the development of diabetes was still preliminary. However three large prospective studies suggest that smoking is associated with the development of type2 diabetes in men and women, consistent with evidence linking smoking and insulin resistance smoking cessation is often accompanied by substantial weight gain and obesity is an important risk factor for development of diabetes. It is not clear whether the benefits of giving up smoking outweigh the adverse effect of weight gain. An earlier report from the British Regional Heart Study based on 11.8 years of follow up observed a significant positive relationship between current cigarette smoking and diabetes after adjustment for age and BMI (Perry et al., 1995). This association was attenuated in the multivariate analyses, which included possible mediating factors but no attempt was made to separate potential confounders from mediating factors. The effects of smoking cessation and of primary and secondary pipe or cigar smoking were not examined.

It has been suggested that smoking may be associated with insulin resistance hyperinsulinaemia and dyslipidemia (Attvall, et al., 1993). Moreover it has been found that among subject with normal glucose tolerance those who smoke have slightly higher HbA1c values than their counterparts. Observation has also indicated that in women heavy smoking may increase risk for developing type2 diabetes mellitus (Rimm et al., 1993).
1.1.6. Diabetes Mellitus and Carbohydrates:

Renner and his colleagues reported that carbohydrates are required by the body as source of energy and for maintenance of blood glucose level, blood glucose may be derived from dietary carbohydrates as well as from glucogenic amino acids and the glycerol moiety of lipids neutral fat could isocalorically replace dietary carbohydrates without affecting growth and blood glucose level. However replacement by fatty acids markedly depressed growth and decreased blood glucose. Supplemental glucose partially overcame this growth depression and blood glucose reduction these effects suggest a specific role of dietary carbohydrates or of glycerol besides providing calories. More recently metabolic effects of carbohydrate free diets were reported in rats (Konijn et al., 1970). Feeding a carbohydrate free diet containing mainly fatty acids (90% of the calories) and limited amounts of protein (10% of the calories) caused loss of weight. Blood glucose was low in the fed state but not after a fast of 24 hours administration of a glucose load resulted in an exaggerated and persistent hyperglycemia when small amounts of glucose were added to the diet, or the fatty acids were replaced by neutral fat, the rats gained weight. Glucose level in the fed state was low and glucose tolerance impaired, though less than in rats fed the fatty acids diet.

Hepatic glucose production is controlled by the reciprocal stimulation/inhibition by hepatic portal venous levels of glucagon and insulin, an increase in both release and the capacity to synthesize glucose by glucocorticoids, primarily cortisol (Wasserman et al., 1990).

Carbohydrates metabolism in diabetes the plethora of glucose outside the cell in diabetes contrasts with the intracellular deficit. Glucose catabolism is normally major source of energy for cellular process and in diabetes energy requirement can be met only by drawing on protein and fat reserves. Mechanisms are activated that greatly increase the catabolism of protein and fat, and one of the consequences of increased fat metabolism is ketosis.

Deficient glucose utilization in the cells of the hypothalamic ventromedial nuclei is probably the cause of the hyperphagia in diabetes. When the activity of the satiety area of nucleus is decrease glucose utilization in its cell, the largest appetite area operates unopposed, and food intake increased. Glycogen depletion is consequence of
intracellular glucose deficit and glycogen content of liver and skeletal muscle in diabetic is usually reduced (Ganong., 2003).

Any disorder in carbohydrates metabolism lead to disorder in lipid metabolism because insulin is the key hormone modulating the metabolism of glucose and lipids (particularly triglycerides and fatty acids). Insulin resistance is defined as diminished tissue responses to insulin at one or more sites in the complex pathways of the hormone action, which is associated with hyperinsulinemia. The biological actions of insulin are exerted through atransmembrane insulin receptor, which leads to the recruitment of insulin receptor substrate.

Insulin also mediates the esterification of free fatty acids (FFA) in adipose tissue and reduces the levels of FFA in blood circulation after meals. In patients with obesity, the levels of postprandial FFA are elevated even with the presence of hyperinsulinemia (Frayn et al., 1996).

**1.1.6.1. Insulin Hormone:**

The Endocrine parts of pancreas consist of the islets of lengerhans. These are clusters of cells are between the acini of exocrine of cells scattered between the acini of exocrine pancreas. The isleted are about 150 micrometers in diameter, they are richly supplied with blood vessels, the cells of islet consist of four main types A cells secrete the glycogen hormone (which constitute 20% of the islets cells) B cells secrete insulin hormones (about 75%) and D cells secrete somatoatain (. 3-5%) F cells <2% release pancreatic polypeptide. It is the key that glucose needs to enter the body's cells so that it can be used as fuel with control the level of blood glucose storage and utilization (Sukkar et al., 2000).

Insulin is a 7000-Da hormone that is produced and secreted by the pancreatic β-cells in the pancreas by usual cell machinery for protein synthesized and that exerts metabolic and mitogenic effects in several target tissues (Myers and White., 1996).

It is carried into the pancreatic vein and goes through the portal vein to the liver before it reaches the systemic circulation. About half of it gets bound to liver cells. Insulin is found in plasma at a basal level (after an overnight fast) of about 5-10 μ U/ml. Overweight and obese patient have higher than fasting level the rate of secretion increased immediately after food intake there are many factor and condition increased and decrease insulin secretion increase blood glucose level stimulates insulin secretion. And increase blood free fatty acid, increase blood amino acids,
gastrointestinal hormones (gastrin, cholecystokinin, secretin, gastricinhibitory peptide), glucogen, growth hormone, cortisol parasympathetic stimulation, insulin resistance (obesity) and sulfonylurea drugs (glyburide, tolbutamide). Decrease blood glucose and fasting, somatostatin catecholamines (α-agonists) they are decrease insulin secretion (Sukkar et al., 2000).

Insulin concentrations are normally determined by feedback control system that is responsive to prevailing level of plasma glucose. Sensitivity of the pancreatic β-cell to glucose is determined by sensitivity of peripheral tissue to the action of insulin with insulin resistance subject having higher insulin levels and insulin secretion rates than insulin sensitive subject (Moitoso et al., 1997).

Insulin resistance was originally defined as a state (of a cell tissue, system or body) in which greater than normal amounts of insulin are required to elicit a quantitatively normal response (Flier and Wiley., 1993). It is said to be present when the ability of insulin to stimulate the uptake and disposal of glucose is impaired (Reaven., 1995). The insulin resistant state is recognized as a major risk factor for CVD, over the last two decades, it has become apparent that a cluster of metabolic abnormalities (variously known as the metabolic syndrome, syndrome X or the insulin resistance syndrome), including hyperinsulinaemia, glucose intolerance an atherogenic lipid profile, hypertension and derangements of the coagulation and inflammatory systems, is intimately associated with insulin resistance. The increased risk of CVD in insulin resistant subjects is most likely due to the associated lipid perturbations, coagulation abnormalities and inflammatory processes rather than the abnormalities in glucose metabolism or hyperinsulinaemia alone (Kannel, 1985; Turner et al., 1998).

Insulin effect on fat metabolism are equally important especially effect of insulin lack in causing extreme atherosclerosis often leading to heart attacks, cerebral strokes and other vascular accident. Insulin has several effects that lead to fat storage in adipose tissue. Insulin increases the utilization of glucose by most of the body's tissues, which automatically decrease the utilization of fat. However insulin also promotes fatty acid synthesis when carbohydrates are ingested than can be used for immediate energy, this synthesis occurs in the liver cells and the fatty acid are then transported from the liver by away of the blood lipoproteins to the adipose cells to be stored. Most of the fatty acid are then synthesized within the liver itself and used to form triglycerides, the usual form of storage fat. Insulin activate lipoprotein lipase in the capillary walls of the adipose tissue which split the triglyceride again into the adipose cells, where
are converted to triglycerides and stored. Insulin inhibits the action of hormones sensitive lipase, the enzyme that causes hydrolysis of the triglyceride already stored in the fat cells. Insulin promotes glucose transport through the cell membrane into fat cell in exactly the same ways that it promotes glucose transport into muscle cells. Immediately after a high carbohydrates meal, the glucose that is absorbed into the blood causes rapid secretion of insulin. Insulin in turn case rapid uptake, storage and use of glucose by almost all tissue of the body especially by the muscle, adipose tissue and liver. Insulin facilitate glucose uptake by many tissues this is achieved by increasing the number of membrane glucose transporters. The glucose transport work through facilitated diffusion. Glucose transport into skeletal muscle and adipose tissue cells depends upon insulin. Some tissues don’t need insulin for glucose entry into their cells like the liver, brain, kidney, red blood cells and intestinal mucosa. Insulin increase glycogen synthesis in the liver and skeletal muscle and decrease the glucose output for the liver by decreasing gluconeogenesis and increase glycogen synthesis and increased the rate of utilization of glucose by skeletal muscle and by adipose tissue (Guyton and Hall., 2001).

1.1.6.2. Hyperglycemia:

Hyperglycemia is an increase in plasma glucose level due to abnormalities in glucose metabolism that are most commonly measured with threshold criteria for fasting plasma glucose (FPG) or 2-h plasma glucose (Petersen et al., 2005).

Major cause of hyperglycemia in diabetes is derangement of the glucostatic function of liver. Liver take up glucose from the bloodstream and stores it as glycogen but because the liver containing glucose 6-phosphate it also discharges glucose into the bloodstream. Hyperglycemia by itself can cause symptoms resulting from the hyperosmolality of the blood (Ganong., 2003).

Hyperglycemia of long duration is associated with structural and functional changes in capillary membranes, blood cells and platelets, nephrons and neurons. Many of these changes are brought about by the accumulation of compounds, the depletion of compounds, or the nonenzymatic linking of glucose and proteins or other macromolecules (Pickup et al., 1991). Improved glycemic control has been reported to result in an improvement or slowed progression of the microvascular complications associated with DM (DCCT Group., 1993).
1.1.6.3. Hypoglycemia:
Hypoglycemia in diabetic patients is an abnormally low concentration of glucose in the blood caused by insufficient food intake, excessive exercise, or overdosage with oral hypoglycemic agents or insulin. The development of hypoglycemia is an ever-present possibility in all patients with diabetes treated with insulin or oral hypoglycemic medications.
Hypoglycemia symptoms are usually accompanied by feeling nervous, shaky, weak, or sweaty. They may have a headache, blurred vision, and be very hungry. In more serious instances they may become unconscious. Taking small amounts of sugar or glucose-containing juice or food will usually help the person feel better within 10–15 minutes (WHO., 1999).
The serious consequences of hypoglycemia relate to its effects on the brain, including loss of cognitive function, seizure, and coma. Prolonged or repeated episodes of hypoglycemia may produce permanent brain damage and the adrenergic response to the condition may be dangerous in people with cardiovascular disease.
The risk of hypoglycemia is particularly high when tight glycaemic control is sought.
In the diabetes control and complications there was a threefold increase in the risk of severe hypoglycemia, including coma and/or seizures, when intensive insulin therapy was used. These episodes may occur with disproportionate frequency at night. Patients with autonomic neuropathy may have greater difficulty in detecting symptoms of hypoglycemia and/or recovering from it. β-adrenoreceptor blockers may also impair detection of symptoms and/or recovery and alcohol consumption may aggravate the risk of hypoglycemia and impair recovery. Delayed or missed meals and increased physical activity increase the risk of hypoglycemia in addition to oral hypoglycemic agents, particularly sulfonylureas, may also induce hypoglycemia (DCCT Group., 1993).

1.2. Normal lipids Metabolism:
Lipids defined as biological substances that are generally hydrophobic in nature and in many cases soluble in organic solvents (Smith., 2000). These chemical properties cover a broad range of molecules, such as fatty acids, phospholipids, sterols, sphingolipids, terpenes, and others (Christie., 2003). Lipid classes are fats, oils, waxes, and complex lipids involved in various biological processes such as sterols, phospholipids, glycolipids, lipoproteins, and sphingolipids (Vilhemsen et al., 2005).
Lipids are first absorbed from the small intestine and emulsified by bile salts which are synthesized from cholesterol in the liver, stored in the gallbladder and secreted following the ingestion of fat. As an emulsion dietary fats are accessible to pancreatic lipase. The products of pancreatic lipase, i.e. free fatty acids (FFA) and a mixture of monoacylglycerols (MG) and diacylglycerols (DG) from dietary TG diffuse into the intestinal epithelial cells where the resynthesis of triacylglycerols occurs.

Lipids are insoluble in plasma, thus their transport is mediated by lipoproteins which differ in particle size, composition and density. These are chylomicrons (CYM), very low density lipoproteins (VLDL), low density lipoproteins (LDL) and high density lipoproteins (HDL). All of them have a hydrophobic core containing TG and cholesteryl ester (CE) and a polar periphery with phospholipids (PL), cholesteryl (C) and apolipoproteins (Mathews et al., 2000).

1.2.1. Diabetes Mellitus and Lipids:
In DM changes in lipid levels and consequent disorders of lipid metabolism and stress have been observed (Betteridge., 1994). Such as increases in circulating levels of free fatty acids (FFA), triglycerides and dense low-density lipoprotein cholesterol particles together with reduced levels of high-density lipoprotein cholesterol levels (Haffner., 1998). It play an important role in pancreatic cell responses (Yaney and Corkey., 2003). FFA provided exogenously or produced in the cell are essential to maintain proper nutrient induced insulin secretion. Acutely FFA generates an increase in glucose induced insulin secretion, whereas chronic exposure to elevated lipids results in cell exhaustion, impaired secretory response to glucose, and eventually, induction of cell apoptosis (Prentki et al., 2002).

The principles abnormal of lipid metabolism in diabetes are acceleration of lipid catabolism, with increased formation of ketone bodies and decreased synthesis of fatty acid and triglycerides. The manifestations of the disordered lipid metabolism are so prominent the diabetes has been called more a disease of lipid than of carbohydrate metabolism. Fifty percent of an ingested glucose load is normally burned to CO2 and H2O 5% is converted to glycogen and 30–40% converted to fat in fat depots.

In diabetes less than 5% converted to fat even though the amount burned to CO2 and H2O is also decreased and the amount converted glycogen is not increased. Therefore, glucose accumulates in the bloodstream and spills over into the urine (Ganong., 2003).
Recent study reported that insulin increases the number of LDL receptor so chronic insulin deficiency might be associated with a diminished level of LDL receptor. These cases the increase in LDL particles and result in increase in LDL cholesterol value in diabetes mellitus (Suryawanshi et al., 2006).

1.2.1.1. Ketoacidosis:

Diabetic ketoacidosis remains a potentially lethal condition with mortality as high as 10%–15% however, at least 50% of cases are avoidable. Many new patients with type1 DM present with ketoacidosis, so early recognition and diagnosis are clearly of importance. Ketoacidosis occurs when the body breaks down fatty acids and produces ketones, which are acidic. Some of the ketone bodies are lost through the urine, but those that remain will build up in the blood and lead to ketoacidosis. Signs of ketoacidosis include: nausea, vomiting, dry skin and mouth deep, rapid breathing, low blood pressure.

If the person is not given fluids and insulin right away ketoacidosis can lead to death. It is crucial to educate patients and health care personnel about precipitating factors and actions to be taken to avoid ketoacidosis. Major precipitating factors include infection and other acute illnesses. In such situations insulin requirements are likely to increase. Omission or insufficient insulin intake is a major cause of diabetic ketoacidosis in some parts of the world. With proper instruction on monitoring of blood glucose and urine ketones, insulin dose adjustment and maintenance of fluid intake, many potential cases of diabetic ketoacidosis can be prevented, if vomiting occurs early referral for intravenous therapy is required.

It is rare for people with type2 diabetes mellitus to develop ketoacidosis. It is much more common for them to develop the hyperglycemic hyperosmolar state in the face of severe infection or other major intercurrent illness. They usually present with dehydration, circulatory compromise and a change in mental state. Acidosis is uncommon, except when related to lactic acidosis due to hypoperfusion.

Serum ketones and electrolytes need to be monitored. Bicarbonate administration for type1 diabetes is not recommended except in severe acidosis (pH <7.1). (WHO., 1994, 1999; Clinical practice recommendations., 2005).
1.2.2. Cholesterol:

Cholesterol is an unsaturated steroid alcohol containing 4 rings (A, B, C and D) it has single C-H side chain tail similar to fatty acid in the physical properties. It is oriented in lipid layers, and can be exist in an esterified form called cholesterol ester (CE). Cholesterol has three types low-density lipoprotein (LDL-C) often called “bad” cholesterol because it carries cholesterol to the tissues of the arteries, causing plaque to build up and the blood vessels to narrow, high-density lipoprotein (HDL-C) it called “good” cholesterol because it helps to keep cholesterol from building up inside your blood vessels and keeps them from getting blocked higher levels of HDL can reduce the risk of cardiovascular disease and very-low density lipoprotein (VLDL-C) this form contains the highest amount of triglyceride like LDL, this is considered “bad cholesterol.” A value less than 32 mg/dl is desirable. VLDL is usually not measured directly and it can be calculated from the other lipoprotein concentrations (Bishop et al., 2004).

In diabetes mellitus the plasma cholesterol level is usually elevated and this plays a role in the accelerated development of the atherosclerotic vascular disease that is a major long term complication of diabetes in human. The rise in plasma cholesterol level is due to an increase in plasma concentration of VLDL and LDL, which may be due to increase hepatic production of VLDL or decrease removal of VLDL and form the circulation (Ganong, 2003).

Hypercholesterolemia in diabetic patients is characterized by high levels of triglycerides (hypertriglycerides), high levels of small LDL particles and low levels of HDL. So dietary intake appears to be one of the most important factors to control level of lipid (Van Dam et al., 2002; Feskens et al., 1995). In addition to Physical activity, it decreases both BMI and central fat accumulation (Gilliat-Wimberly et al., 2001) and can partly counterbalance the negative age related changes in lipid spectrum and increase in BMI by diminution of HDL decrease. The changes in lipids due to physical activity are largely independent of changes in body weight (Owens et al., 1992).
1.2.3. Triglycerides:

Triglycerides is the most common type of lipid formed in animals it contain three fatty acid molecules attached to one molecule of glycerol by ester bond and containing saturated fatty acid which do not have kinks in their structure, pack together more closely and tend to be solid at room temperature. In contrast triglycerides containing cis unsaturated fatty acid with bends in their structure, typically from oils at room temperature (Bishop., 2004). Triacylglycerol (TG) is stored in lipid droplets in the cytoplasm of skeletal muscle. They can be mobilized by catecholamine, exercise and electrical stimulation the exercise induced decrease of TG can be reduced by Beta-adrenergic blockade. The effect of catecholamine on intramuscular TG is compatible with a role of hormone sensitive lipase (HSL) in muscle. A value below 150 mg/dl indicates no increased risk, 150 -200 indicates a slight risk, and over 200 mg/dl is a high risk.

Recent studies have demonstrated that in diabetic patients TG levels is a risk factor for CVD independent of HDL-C level and despite glycemic control, the incidence of macrovascular disease is increased two to five-fold in diabetics as compared to nondiabetic patients. This is attributed mainly to diabetic dyslipidemia (Stamler et al., 1993).

1.2.3.1. Diabetes Mellitus and Dyslipidemia:

Dyslipidaemia in diabetic patients characterized by elevated triglyceride levels and decreased HDL cholesterol levels triglycerides are considered to have atherogenic properties. HDL is considered a protective lipoprotein because it contributes to reverse cholesterol transport (WHO.,2006). Dyslipidemia is common in diabetes and may contribute significantly to the excess risk of cardiovascular disease (CVD) among patients with type2 diabetes (Garg and Grundy., 1990). Type2 diabetic patients typically have a preponderance of small, dense LDL particles, which possibly increases atherogenicity by a greater susceptibility to oxidation even if the absolute concentration of LDL cholesterol is not significantly increased. Hypertriglyceridemia often is rather modest. As in non-diabetic individuals, lipid levels may be affected by factors unrelated to hyperglycemia or insulin resistance, such as renal disease, hypothyroidism and genetically determined lipoprotein disorders. Abuse of alcohol and estrogen replacement therapy may also contribute to hypertriglyceridemia. In well controlled patients with type1 diabetes there is only a small difference in plasma lipid
levels compared with non-diabetic subjects. However, noticeable abnormalities in lipoprotein composition are observed in these patients despite good glycaemic control and near normal plasma lipid levels (Patti et al., 1995; Winocour et al., 1992).

1.2.4. Diabetes Mellitus and Hypertension:
Hypertension is defined as a blood pressure is more than 140 systolic and 90 in diastolic (Chobanian et al., 2003). Increased blood pressure is a major risk factor for cardiovascular disease particular in diabetic patients. In the UKPDS, a 15 % increased risk for cardiovascular disease was reported for an elevation in systolic blood pressure of 10 mmHg, which was similar to that reported in the general population (MacMahon et al., 1990). Multiple studies have demonstrated that control of hypertension reduces the microvascular complications of diabetes particularly nephropathy. Hypertension occurs in approximately 50% of people with type2 diabetes and is part of the insulin resistance syndrome and it may exist prior to the onset of hyperglycemia and is often labeled essential hypertension. In contrast, hypertension in people with type1 diabetes is usually a marker of diabetic nephropathy. Because of the importance of hypertension in people with diabetes, most authorities recommend treatment goals of Bp <130/85 which is more rigorous than the recommendations in people without diabetes (Howard et al., 1996).

1.3. Diabetes Mellitus and Health Care:
Diabetes mellitus is a complex chronic disease that requires numerous skills for optimal management. So that people with diabetes require at least 2-3 times the health care resources of people who do not have diabetes (Rice and Jack., 2006). Improving the quality of care for patients with diabetes and other chronic conditions is an important aim of health policy and providers in many countries throughout the world. In countries like U.S, disease management programs (DMPs), defined as structured, multifaceted, systematic approaches to provide better care (Krumholz et al., 2006). Measurement of blood glucose is required for appropriate diabetes management, particularly for adjustment of insulin. If the BG results are inaccurate, there is a potential for serious consequences from therapeutic errors (Winter., 2004).
Many people with diabetes do not have access to diabetes education or to a diabetes care team to assist them. The importance of BG control has been substantiated over the last two decades. Recent research has focused on tight glycemic control in the hospital setting for all patients and for patients with diabetes in particular.
Tight glucose control has been shown to have a dramatic positive effect on morbidity, mortality and costs (Clement et al., 2004; Van den Berghe et al., 2001). Harris and his colleagues studies the racial disparities in the quality of diabetes care are well documented, with black patients less likely than white patients to achieve adequate control of glucose or cholesterol levels or blood pressure (Harris et al., 2001). Limited evidence is available for devising effective solutions that address these differences in quality and outcomes and disparities persist in such intermediate outcomes as lipid control (Lurie et al., 2005). Primary care clinicians represent the front line in the delivery of effective diabetes care (Rothman and Wagner, 2003). And can play an important role in addressing racial disparities. Black patients report more lower-quality care experiences with physicians than do white patients and often perceive bias in health care delivery (Cooper et al., 2006; Johnson et al., 2004). The lack of awareness represents a barrier to improving health care for minority patients, particularly when evidence suggests that patient race has a subtle but important influence on clinical decision making by physicians (Schulman et al., 1999).

Cultural competency training to provide insights into caring for a diverse patient population may increase clinician awareness and improve care for black diabetic patients however, investigators have questioned the rigor of previous studies of such training, and data on its effect on clinical outcomes are limited. We conducted a cluster randomized, controlled trial to assess the combined effect of cultural competency training and race-stratified performance reports for primary care clinicians on their awareness of racial disparities in diabetes care and on control of glucose level, cholesterol level, and blood pressure among their black diabetic patients. We also assessed whether these efforts reduced racial differences between white and black patients for these measures of diabetes care (Beach et al., 2005; Price et al., 2005).

Some studies indicates that men and women differ in behavior and attitudes toward their diabetes, women tend to regulate their diabetes through diet, but they exercise less than men (Nothwehr and Stump, 2000), report more negative impacts of diabetes, and use the health care system more often than men. Thus women have poorer glycolic control than men, but others report no sex difference. Social support and knowledge of one’s own diabetes are essential for diabetes management (Campbell et al., 2003).
1.4. Diabetes Mellitus and Sex Dysfunction:

Diabetes has long been considered a major cause of impaired sexual function, diabetic men have been shown to have substantially increased risk of erectile dysfunction (ED). Beyond the effects of comorbidities, such as older age, use of antihypertensive medication, high BMI, and smoking, the severity and duration of diabetes and its vascular and neurological complications, which cause abnormalities in the endothelium or nitric oxide related mechanisms in the corpora cavernosa, have been strongly linked with the development of sexual dysfunction in men (Brown et al., 2005; Rosen et al., 2005; Lauman et al., 1999; Rhodenet et al., 2005).

Several observational studies have reported an association of insulin resistance with low serum testosterone concentrations in men. This is consistent with a short-term trial of testosterone supplementation in obese men showing improved insulin sensitivity (Bataille et al., 2005). However, there are inconsistencies in the strength and significance of the association between testosterone and markers of insulin resistance or diabetes risk because of differences in study design, characteristics of the populations studied, testosterone assay methodology, and covariates used for adjustment. Moreover, sex hormone binding globulin (SHBG), which binds tightly to testosterone and transports it in the circulation, has emerged as a stronger correlate with insulin resistance, central adiposity and dyslipidemia (Turner et al., 1998).

Low SHBG level was independently associated with increased risk of diabetes in men therefore, it is likely that SHBG confounds the association between testosterone and insulin resistance (Tsai et al., 2004).

Women with diabetes have similar rates of cardiovascular and neurological complications, and therefore similar rates of sexual dysfunction might be anticipated. Sexual functioning of women with diabetes, however, has received far less attention in research, and results are less conclusive than those of studies in men (Enzlin et al., 1998). In general, studies of sexual dysfunction in women have lagged behind those in men, likely due to several factors, including a lack of standardized definitions of sexual dysfunction in women, absence of well validated scales, and societal taboos regarding female sexuality (Rosen and Rosen., 2006; Althof et al., 2005).

Preliminary reports have noted a high prevalence of sexual dysfunction in women with diabetes, in particular a mixed pattern of sexual symptoms has been found, including loss of sexual interest or desire, arousal or lubrication difficulties, painful
intercourse (dyspareunia) and loss of the ability to reach orgasm. In recent study women with type 1 diabetes had increased rates of sexual dysfunction compared with age matched control subjects. Another study further revealed that sexual dysfunction in women with diabetes is related more directly to psychological factors, i.e., the presence of depression was found to be the major predictor of female sexual dysfunction (FSD) (Enzlin et al., 2003). This latter finding is consistent with other studies showing depression to be a major risk and comorbid factor of FSD.
CHAPTER TWO
MATERIALS AND METHODS

2.1. Subjects:
This study was conducted during January 2009 in Khartoum, the largest city of the
country it had an estimated total population of approximately 6 million people
according to national population census in 2009, venous blood samples were obtained
from people aged 23 years to 80 years. Blood samples were transferred to the central
lab for separation and Aljazeera laboratory to be analyzed by colorimetric method.
One hundred Sudanese diabetic patients were randomly selected from Ribat university
hospital they were coming from different parts of Sudan. They had mean age of (52 ±
11.063) years, a mean height of (165.82 ±8.573) cm and a mean weight of
(70.20±11.203) Kg and (25.5915±4.05637) Kg/m² mean of BMI.
Fifty apparently healthy non diabetic persons from the same hospital were chosen as
controls. Their mean age was (45.72 ± 11.169) years, mean height was (167.28 ±
9.450) cm and mean of weight was (71.02 ± 13.429) Kg and (25.3248±3.90677)
Kg/m² mean of BMI.
All patients underwent a clinical and laboratory evaluation and answered standardized
questionnaire. A blood samples for glucose level, total cholesterol, triglyceride, low-
density lipoprotein high–density lipoprotein cholesterol were measured for each
subject (diabetic and non-diabetic)

2.2. Materials:

2.2.1. Questionnaire:
Information’s were taken from each subject about, treatment, family history of
diabetes and other diseases and complication
Both Patients and control subjects were interviewed at the hospital, main questioner
data of patients can be summarized as fallowing (Annex1).

- General information: Age, sex, residence, occupation, level of education,
  smoking and alcohol concentration.
- Clinical profile: Type of diabetes, treatment, if they suffer from any disease
- Patients were asked to report any hospital admission and the reason for
  admission, if they have ever had foot ulcers (whether these had been seen by the
doctor, and who treated the ulcer).
• Laboratory investigations: Patients were asked about renal function test, liver function test, cholesterol, triglyceride and ECG (Regular routine test every six month).
• Foods and exercises: Patients were asked about their eating habits and if they are performing any regular exercise.
• Sex performance: If they knew the effects of diabetes on the sex performance, if there is any difference between sex rate before and after diabetes, if they had any observation about sex performance and glucose level, if they have ever had treatment.

2.2.2. Equipment and Disposables:
The following list of equipment and consumables were used to perform different experiments and measurements.
1- Colorimeter (LAB TECH) capable of measuring absorbance at (500-550) nm.
2- Pipettes (10 µL-1000µL) and disposable tips.
3- Centrifuge EBA20 tettich from Germany.
4- Plain Blood containers.
5- Floride blood containers.
6- Storage tubes.
7- Antiseptic swab.
8- Disposable stale syringe 5 ml.

2.3. Reagents for Glucose and Lipid Profile:
Glucose and lipid profile were measured using reagent and standard obtained from Biosystem and spectrum (Spain& Germany 2008).

2.3.1. Glucose:
Glucose spectrum diagnostic liquizme is intended for the in-vitro quantitative diagnostic determination of glucose in human serum or plasma.
Glucose standard (St) 100mg/dL  5.55mmol/L
Reagent (R) is content
Phosphate Buffer    100 mmol/L.
Phenol            4.0 mmol/L.
4-amino-antipyrine 1.0 mmol/L.
Glucose oxidized   >20KU/L.
peroxidase        >2.0KU/L.
Sodium Azide  8.0 mmol/L.

2.3.2. Triglycerides:

Standard Triglycerides (St)  200 mg/dL, 2.29 mmol/L.

Reagent (R) is content

Pipes Buffer PH 7.0  50 mmol/L.
4-Chlorophenol  6.0 mmol/L.
Magnesium aspartate  >0.5 mmol/L.
Lipase  >10 KU/L.
Peroxidase  >2.0 KU/L.
4-aminoantipyrine  1.0 mmol/L.
Glycerol-3-phosphate oxidase  >3.5U/L.
ATP  1.0 mmol/L.
Sodium Azide  8.0 mmol/L.

2.3.3. Cholesterol:

Cholesterol standard (St)  200 mg/ dL -  5.17 m mol/L.

Reagent (R) is content

Pipes Buffer PH 7.0  50 mmol/L.
Phenol  30 mmol/L.
Sodium cholate  5.0 mmol/L.
Cholestrol esterase  >250U/L.
cholestrol oxidase  >500U/L.
peroxidase  >2.0 KU/L.
4-amino-antipyrine  1.0 mmol/L.
Sodium Azide  8.0 mmol/L.

2.3.4. HDL-Cholesterol:

Reagent (R) is content

Phosphotungstate  0.52 mmol/L.
Magnesium chloride  30 mmol/L.

Reagents also contain non-reactive stabilizers and surfactants.

Supplementary reagent: A pack for spectrum liquizyme cholesterol reagent required.
2.3.5. LDL–Cholesterol:
Reagent $1 \times 20$ ml
polyvinylsulphate 3g/L
polythleneglycol 3g/L.

2.3.6. VLDL – cholesterol:
VLDL values not measured directly; it calculated by dividing serum TG by 5 (TG/5).

2.4. Methodology:
2.4.1. Blood Samples:
After approximately 12 hours fasting period 5 ml of venous blood in dry sterile syringe were collected from each subject (patients and controls). The blood was divided into 2 tubes. 2 ml was mixed with florid oxalate in fluoride blood container for blood glucose measurement and 3 ml were allowed to clot and immediately centrifuged at 2000 r.p.m for 10 minutes and sera was used for lipids profile test during 1-2 days.
Glucose and lipid profile (total cholesterol, triglycerides, LDL-cholesterol, HDL-cholesterol) were measured by enzymatic methods.

2.4.2. General Principle of Colorimetric Methods:
Beer's law: The fraction of monochromatic radiant energy absorbed on passing through a solution is directly proportional to concentration of absorber. It is a relationship between the light absorptive capacity and concentration of the absorbance in solution (Sharma., 2001). According to the following equation concentration of sample can be calculated.

$$A \text{(absorbance) of sample} \times \text{Concentration of standard mg/dL.}$$

$$A \text{(absorbance) of standard}$$

2.4.2.1. Principle of Determination Blood Glucose:
Glucose determined after enzymatic oxidation by the glucose oxidase (GOD). The formed hydrogen peroxide reacts under catalysis of peroxidase (POD) with phenol and 4-aminantipyrine (4-AA) to form a red violet quinoneimine dye as indicator.

$$\text{Glucose} + \text{H}_2\text{O} \xrightarrow{\text{GOD}} \text{Gluconic acid} + \text{H}_2\text{O}_2$$
$$2\text{H}_2\text{O}_2 + \text{phenol} + 4\text{-AA} \xrightarrow{\text{POD}} \text{Quinoneimine} + 4\text{H}_2\text{O}$$
Glucose was determined using the following assay protocol

- All reagents and specimens were brought to room temperature.
- In labeled test tubes the following were pipetted.

<table>
<thead>
<tr>
<th>Tubes</th>
<th>Blank</th>
<th>Standard</th>
<th>Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working solution</td>
<td>1.0 ml</td>
<td>1.0 ml</td>
<td>1.0 ml</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td>10 µl</td>
<td></td>
</tr>
<tr>
<td>Specimen</td>
<td></td>
<td></td>
<td>10 µl</td>
</tr>
</tbody>
</table>

- All tubes were mixed and incubated for 10 minutes at room temperature.
- The absorbance of specimen (A Specimen) and standard (A standard) were measured at 510 nm within 30 minits against blank.

Glucose concentration (mg/dL) = \( \frac{(A \text{ Specimen})}{(A \text{ standard})} \times 100 \)

2.4.2.2. Principle of Determination Triglycerides:

The method is based on the enzymatic hydrolysis of serum triglyceride and free fatty acid (FFA) by lipoprotein lipase (LPL) to glycerol.

Triglycerides \( \xrightarrow{\text{LPL}} \) Glycerol + Fatty acid

Glycerol is phosphorylated in the presence of glycerol kinase (GK) to glycerol-3-phosphat by adenosine triphosphate (ATP).

Glycerol + ATP \( \xrightarrow{\text{GK}} \) Glycerol-3-phosphate + ADP

Glycerol-3-phosphat is oxidized by glycerol phosphate oxidase (GPO) to form dihydroxyacetone phosphate (DHAP) and hydrogen peroxide (H2O2).

Glycerol-3-phosphate + O2 \( \xrightarrow{\text{GPO}} \) Dihydroxyacetone phosphate + H2O2

A red color quinoneimine dye is produced by the peroxidase (POD) catalyzed coupling of 4-chlorophenol and 4-aminoantipyrine (4AAP) with hydrogen peroxide (H2O2) proportional to the concentration of triglyceride in sample which is measured at 546 nm.

\[ 2\text{H}_2\text{O}_2 + 4\text{AAP} + 4\text{Choleatrol} \xrightarrow{\text{POD}} \text{Quinoneimine dye} + 4\text{H}_2\text{O} \]
Triglyceride was determined using the following assay protocol

- All reagents and specimens were brought to room temperature.
- In labeled test tubes the following were pipetted.

<table>
<thead>
<tr>
<th>Tubes</th>
<th>Blank</th>
<th>Standard</th>
<th>Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagent</td>
<td>1.0 ml</td>
<td>1.0 ml</td>
<td>1.0 ml</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td>10 µl</td>
<td></td>
</tr>
<tr>
<td>Specimen</td>
<td></td>
<td></td>
<td>10 µl</td>
</tr>
</tbody>
</table>

- All the tubes mixed and incubated for 5 minutes at room temperature.
- The absorbance of specimen (A Specimen) and standard (A standard) were measured at 510 nm within 30minits against blank.

\[
\text{Triglyceride concentration (mg/dL) = } \frac{(A \text{ Specimen})}{(A \text{ standard})} \times 200
\]

2.4.2.3. Principle of Determination Cholesterol:

The method for the measurement of total cholesterol in the serum is based on three enzyme: Cholesterol esterase (CE), cholesterol oxidase (CO) and peroxidase (POD). Cholesterol esters hydrolyzed by cholesterol ester (CE) to cholesterol and free fatty acid.

\[
\text{Cholesterol ester } \rightarrow_{CE} \text{ Cholesterol + Free Fatty acid.}
\]

Free cholesterol oxidized by cholesterol oxidase (CO) to cholesterol -4-en-3-one and hydrogen peroxide.

\[
\text{Cholesterol } + \text{O2 } \rightarrow_{CHOD} \text{ Cholesterol 4-en-3-one +H2O2}
\]

The hydrogen peroxide combined with phenol and 4- aminoantipyrine (4AAP) in the presence of peroxidase (POD) to form achromophore Quinoneimine dye.

\[
\text{H2O2+ phenole } \rightarrow_{POD} \text{ Quinoneimine dye +4H2O2}
\]

Cholesterol was determined using the following assay protocol.

- All reagents and specimens were brought to room temperature.
- In labeled test tubes the following were pipetted.
All the tubes mixed and incubated for 5 minutes at room temperature.

The absorbance of specimen (A Specimen) and standard (A standard) were measured at 510 nm within 30 minutes against blank.

\[
\text{Cholesterol concentration (mg/dL) = } (A \text{ Specimen}) \times 200/ (A \text{ standard})
\]

2.4.2.4 Principle of Determination HDL-Cholesterol:

The method for the measurement high density lipoprotein (HDL) is depend on the precipitation of low density lipoprotein (LDL) and very low density lipoprotein (VLDL) in sample with phosphotungstate and magnesium ion. After centrifugation the cholesterol concentration in the HDL fraction which remains in the supernatant, is determined.

\[
\begin{align*}
\text{Cholestrol ester} + \text{H}_{2}\text{O}_2 & \xrightarrow{\text{chol. esterase}} \text{Cholesterol} + \text{Free Fatty acid} \\
\text{Cholestrol} + 1/2\text{O}_2 + \text{H}_2\text{O} & \xrightarrow{\text{chol. Oxidase}} \text{Cholestenone} + 4\text{H}_2\text{O} \\
2\text{H}_2\text{O} + 4\text{-Aminoantipyrine} + \text{phenole} & \xrightarrow{\text{peroxidase}} \text{Quinoneimine dye} + 4\text{H}_2\text{O}
\end{align*}
\]

- HDL - Cholesterol was determined using the following assay protocol.
- All reagents and specimens were brought to room temperature.
- In labeled test tubes the following were pipetted.

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5ml</td>
<td>0.2ml</td>
</tr>
</tbody>
</table>

- The tubes were mixed and incubated for 10 minutes at room temperature.
- Centrifuged for 10 minutes at 4000 r.p.m.
- The supernatant was collected carefully.
- In label test tubes the following were pipetted.
### HDL-Cholesterol Concentration Measurement

- All the tubes mixed and incubated for 5 minutes at room temperature.
- The absorbance of specimen (A Specimen) and standard (A Standard) were measured at 510 nm within 60 minutes against blank.

HDL – cholesterol concentration (mg/dL) = A Specimen x 570.

### 2.4.2.5. Principle of Determination LDL-Cholesterol:

Low density lipoprotein (LDL) in the sample precipitation with polyvinyl sulphate. Their concentration is calculated from different between the serum total cholesterol and cholesterol in the supernatant centrifugation. The cholesterol is spectrophotometrically measured by means of following coupled reaction.

- **Cholesterol ester + H₂O → Cholesteryl**
- **Cholesterol + Free Fatty acid**
- **Cholesterol + 1/2O₂ + H₂O → Cholestenone + H₂O**
- **2H₂O + 4-Aminoantipyrine + phenole → Quinoneimine dye + 4H₂O**

- In labeled test tubes the following were pipetted.

| Reagent (Cholesterol LDL kit) | 0.2ml |
| Specimen                      | 0.4ml |

- The tubes were mixed and incubated for 15 minutes at room temperature.
- Centrifuged for 15 minutes at 4000 r.p.m.
- The supernatant was collected carefully.
• All tubes were mixed and incubated for 10 minutes at room temperature.
• The absorbance of specimen (A Specimen) and standard (A standard) were measured at 500-550 nm within 60 minutes against blank.

\[ \text{LDL (mg/dL)} = \frac{(A \text{ Specimen}) \times \text{C standard} \times \text{sample dilution factor}}{(A \text{ standard})} \]

2.5. Statistical Analysis:

Statistical analysis was performed by use of SPSS version 16 (Statistical Package for the Social Sciences).

The differences between the groups were tested for significance by student’s t-test, one way ANOVA test and chi-square test.

Data were expressed as the mean ± SD. P-values < 0.05 are considered statistically significant. Also correlations were considered significant at p<0.05.
CHAPTER THREE

RESULTS

3.1. Preamble:

This study was a hospital based, cross sectional study to compare blood glucose level and lipid profile concentration in diabetic and non-diabetic subjects. In addition to assess healthcare standards and patients knowledge among diabetic patients.

To perform this, comparison analysis was done to see if there is any difference between controls and patients. An attempt was done to correlate between all parameters. The study group was divided into subgroups, insulin dependent diabetes mellitus (Type1) and non-insulin dependent diabetes mellitus (Type2) and males and females diabetic groups to find if there’s any difference between subgroups also an attempt was done to see if there is any correlation between different parameters in male and female subgroups. The results of this study covered one hundred known diabetic patients and 50 healthy (non-diabetic) controls, 16% of patient’s type1 and 84% type2. Data collected from both diabetic patients and control subjects from Ribat university hospital diabetes and endocrinology clinic. They were from different parts of Sudan. The majority of the patients were elementary educated, 59% of patients were found to be with family history of the disease (inherited). All patients were under the treatment for diabetes.

Table (3.1). Represents the mean age, height, weight and body mass index. Patients and control subjects were both overweight.

Plasma glucose level and Serum lipid profile (total cholesterol (TC), triglyceride (TG), Low–density lipoprotein cholesterol (LDL-C), High–density lipoprotein cholesterol (HDL-C), were measured and Very low-density lipoprotein cholesterol (VLDL-C) was calculated. The mean and standard deviation (SD) of all parameters were reported.
Table 3.1: Essential Physical Data of Diabetic Patients and Control Subjects (Mean ± SD).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Diabetic Patients</th>
<th>Control Subjects</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (YR)</td>
<td>52.00 ± 11.063</td>
<td>45.72±11.169</td>
<td>0.002</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>70.20±11.203</td>
<td>71.02±13.429</td>
<td>0.711</td>
</tr>
<tr>
<td>Height (Cm)</td>
<td>165.82 ±8.573</td>
<td>167.28±9.450</td>
<td>0.360</td>
</tr>
<tr>
<td>BMI (kg/ m²)</td>
<td>25.59±4.05637</td>
<td>25.32±3.90677</td>
<td>0.698</td>
</tr>
</tbody>
</table>

3.2. Blood Glucose Level:

The mean of (FBG) level of diabetic patients was significantly (p=0.001) higher than that of the non diabetic subjects as shown in table (3.2)

3.3. Lipid Profile: TC, TG, LDL, HDL and VLDL Concentrations

All serum lipid and lipoproteins were significantly higher in diabetic patients compared to non diabetic subjects except HLD-C which is significantly lower in diabetic patients compared to non-diabetic subjects.

Cholesterol mean level value in diabetic patients was significantly higher than the mean serum of non diabetic subjects (p=0.001).

Mean value of triglycerides in diabetic patients was significantly (p=0.001) increased compared to mean of non diabetic subjects.

LDL-Cholesterol mean value in diabetic patients was statistically significant (p=0.001) higher than the mean value of non diabetic subjects.

Serum HDL-Cholesterol mean value was significantly (p= 0.001) lower in diabetic patients compared to the mean of non diabetic subjects.

VLDL-Cholesterol mean value in diabetic patients was significantly (P=0.001) increased compared to mean of non diabetic subjects. As shown in table (3.2).

Same results (p<0.05) were found when we compared glucose and lipid profile (TC, TG, LDL, HDL and VLDL) in subgroups (type1 and type2) and control subjects. As shown in figures (3.1)
Table 3.2: Levels of Glucose and Serum Lipid Profile in Diabetic Patients and Control Subjects.

<table>
<thead>
<tr>
<th>Measurement (mg/dL)</th>
<th>Diabetic patients (Mean ± SD)</th>
<th>Non-Diabetic subjects (Mean ± SD)</th>
<th>p- value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GL</td>
<td>159.00±63.9692</td>
<td>81.00±16.247)</td>
<td>0.001</td>
</tr>
<tr>
<td>TC</td>
<td>176.80±36.0918</td>
<td>144.91±34.1804</td>
<td>0.001</td>
</tr>
<tr>
<td>TG</td>
<td>137.91±59.0534</td>
<td>111.04±29.8395</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL</td>
<td>151.22±64.0362</td>
<td>117.71±26.2479</td>
<td>0.001</td>
</tr>
<tr>
<td>HDL</td>
<td>44.80±15.7758</td>
<td>51.89±10.5376</td>
<td>0.001</td>
</tr>
<tr>
<td>VLDL</td>
<td>27.58±11.811</td>
<td>22.21±5.968</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Figure 3.1: Mean values of glucose and lipid profile (TC, TG, LDL, HDL, VLDL mg/dl) of type1 and type2 diabetic patients and non-diabetic subjects.
3.4. Gender and Diabetic Patients:

Among diabetic patients, males had higher level of glucose, triglycerides, LDL, HDL and VLDL and lower level of cholesterol as compared to females. This differences were statistically not significant (p>0.05). As shown in table (3.3).

Table 3.3: Levels of Glucose and Lipid Profile in Males and Females Diabetic Patients.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Female diabetic patients (Mean ± SD)</th>
<th>Male diabetic patients (Mean ± SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GL</td>
<td>153.720±59.2818</td>
<td>164.280±68.530</td>
<td>0.412</td>
</tr>
<tr>
<td>TC</td>
<td>180.118±38.4228</td>
<td>173.496±33.6621</td>
<td>0.362</td>
</tr>
<tr>
<td>TG</td>
<td>133.250±46.6038</td>
<td>142.580±69.4943</td>
<td>0.433</td>
</tr>
<tr>
<td>LDL</td>
<td>142.966±65.2019</td>
<td>159.482±62.4058</td>
<td>0.199</td>
</tr>
<tr>
<td>HDL</td>
<td>43.746±15.1988</td>
<td>45.856±16.4182</td>
<td>0.506</td>
</tr>
<tr>
<td>VLDL</td>
<td>26.65 ±9.321</td>
<td>28.52 ±13.899</td>
<td>0.433</td>
</tr>
</tbody>
</table>
3.5. Healthcare of Diabetic Patients:

3.5.1. Background Characteristics and History of Patients:

The assessment of patient’s knowledge showed the majority of patients were elementary educated and they were taking oral hypoglycemic drugs, most of them were suffering from diabetes mellitus one to five years and 59% of them inherited as shown in figure (3.2).

![Figure 3.2: Percentage of Diabetes Duration (years)](image)

3.5.2. Clinical Profile of Diabetes Care:

The study showed 38% of patients were never undertook eye test and did not know the effect of diabetes on the eye. 52% of patients did not perform renal function test and 51% of them did not do liver function test. Only 24% of patients conducted ECG. One half of the patients were followed-up by the doctors systematically and 64% of them measure their blood glucose and check their urine monthly.

3.5.3. Food System and Physical Activity:

The study reported that 66% of the patients have not had a nutritionist check-up and more than half had never had a food system. Most of the female patients did not practice exercise as of shown in figure (3.3).
3.5.4. Sex Performance in Diabetic Patients:

The assessment of sex performance in this study showed only 26% of patients were known the effect of diabetes on the sex performance while the majority of males observed decrease in sex rate compared to diabetic females as shown in figure (3.4).

72% of males and 6% of females diabetic observed there were a relation between sex practice and concentration of glucose level. Only 8% of diabetic males were using doping.

Figure 3.4: Percentage of Diabetic Patients Observed Decrease in Sex Rate by Gender.
3.6. Correlation Between Glucose and Lipid Profile:

Fasting blood glucose was correlated positively with the levels of serum cholesterol 
\( r=0.02 \), triglyceride \( r=0.052 \), LDL-C \( r=0.023 \) and VLDL-C \( r=0.056 \) and 
negatively correlation with HDL-C \( r=0.028 \) as shown in figure (3.4). 
Correlation analyses were also carried out between serum cholesterol and 
triglycerides and lipoproteins. Cholesterol level correlated positively with triglyceride 
\( r=0.000226 \), LDL-C \( r=0.097 \), VLDL-C \( r=0.000226 \) and negatively with HDL-C 
\( r=0.000399 \).

Further correlation analyses were conducted between triglycerides and LDL-C \( r = 
0.016 \), positive correlation was obtained, while negative correlation was obtained 
with HDL- C \( r=0.102 \). As shown in figure (3.5).

Among male and female diabetic patients statistical negative correlations was 
obtained between glucose level and serum cholesterol, VLDL-Cholesterol and HDL-
Cholesterol \( r=0.018 \), \( r=0.015 \), \( r=0.02 \) respectively and positive linear correlation 
between blood glucose level and serum triglyceride \( r=0.015 \). LDL-Cholesterol 
\( r=0.0029 \).

Further correlation studies were conducted between plasma glucose, cholesterol, 
triglyceride, LDL-C, HDL-C, VLDL-C and duration of diabetes. A statistically 
significant positive correlation was obtained, \( r=0.070 \), \( r=0.023 \), \( r=0.009 \), 
\( r=0.0075 \), \( r=0.009 \) respectively. While with HDL \( r=0.12 \), a statistically 
significant negative correlation was obtained.
Figure 3.4: Correlation Between Concentrations of Glucose and Cholesterol
Figure 3.5: Correlation Between Concentrations of Triglyceride and HDL-Cholesterol.
CHAPTER FOUR
DISCUSSION

4.1. Prevalence of Diabetes Mellitus:

The incidence of diabetes mellitus and its complications is markedly increasing in Sudan as well as in the different part of the world according to the WHO and researches took place in Sudan (Guidelines for diagnosis & management of DM., 2008; WHO., 1999).

All these reasons lead to increase of diabetes mellitus complications. Up normal levels of lipids profile one of the complications. In the present study we determined the prevalence of lipid profile. Furthermore healthcare standards and patients knowledge among Sudanese diabetic patients.

4.2. Glucose Level:

Diabetic patients are characterized by abnormalities in glucose metabolism in several organs, skeletal muscle glucose disposal is reduced, hepatic glucose production is increased and insulin-independent glucose uptake into the lens and neural tissue are increased (DeFronzo., 1988; Greene et al., 1987). Although the actual mechanisms of insulin resistance in type2 diabetes remain unknown, several steps in the uptake and intracellular handling of glucose are probably affected (Eriksson et al., 1992; Del Prato et al., 1993). Measuring blood glucose is one way of monitoring diabetes.

In this study diabetic patients have abnormal level in blood glucose compared with non diabetic subjects. Significant difference was observed (p=0.001), the same result (p=0. 0.001) was found between diabetic subgroups (Type1 and type2) and control subjects. High levels of blood glucose of diabetic patients due to lack of or resistance to insulin, same results were found by (Richard et al., 2008, Abdelgadir., 2006, Elbagier., 1996). In their studies of diabetic population in which they conclude that, the fasting blood glucose level is also elevated and this indicates poor control of DM. In fact diabetes mellitus is characterized by hyperglycemia together with biochemical alterations of glucose (Pari and Latha., 2002).

4.3. Lipid Profile:

Lipid and lipoprotein abnormalities are common in the diabetic population due to the effects of insulin deficiency and insulin resistance on key metabolic enzymes (Decode study group., 1999). Glucose tolerance, insulin resistance and plasma insulin levels have been implicated in abnormal plasma lipoprotein levels and hyperinsulinaemia
has been linked with the development of atherosclerotic vascular complications in diabetic patients (Simons et al., 2001; UKPDS., 2000).

The result of this study showed significant increased levels of total cholesterol (p=0.001) in diabetic patients compared to non-diabetic subjects, this increase it may be due to an increase in the plasma concentration of VLDL and LDL, which may be due to increase hepatic production of VLDL or decreased removal of VLDL and LDL from the circulation (Ganong, 2003).

The study suggest significant increased level of LDL (p=0.001) in diabetic patients due to insulin increases the number of LDL receptor, so chronic insulin deficiency might be associated with a diminished level of LDL receptor. This causes the increase in LDL particles and result in the increase in LDL-cholesterol value in diabetes mellitus (Suryawanshi et al., 2006). So that patients with small, dense LDL-C will also typically have lower HDL-C and elevated TG blood levels, which may further increase risk of atherosclerosis (Bays, 2003).

Significant higher level of triglycerides (p= 0.001) in Sudanese diabetic patients may due to overproduction of VLDL lead to increased plasma levels of triglyceride which, via an exchange process mediated by cholesterol ester transfer protein (CETP), result in lower levels of high density lipoprotein HDL-cholesterol, also may be due to insulin deficiency which results faulty glucose utilization causes hyperglycemia and mobilization of fatty acids from adipose tissue. In diabetes blood glucose is not utilized by tissue resulting in hyperglycemia. The fatty acids from adipose tissue are mobilized for energy purpose and excess fatty acid is accumulated in the liver, which are converted to triglyceride (Shih et al., 1997). The most frequent alterations of lipid profile were combination of elevated TGs (VLDL-TG), decreased clearance of TG-rich lipoproteins and decreased high-density lipoproteins HDL-C (Gowri et al., 1999). Significant higher level of VLDL (p=0.001) in Sudanese diabetic patients, an increase in VLDL occurred in diabetes mellitus due to increase availability of glucose for VLDL synthesis and decrease in lipoprotein lipase activity leading to decrease of VLDL from peripheral circulation. An increased percent body fat was identified with higher levels of TC and decreased HDL-C due to decrease in hepatic lipase activity resulting in decrease VLDL clearances which are metabolic abnormalities characterizing metabolic syndrome (Imamura et al., 1993).

Significant lower level of HDL (p=0.001) in diabetic patients compared to non-diabetic subjects. Lower HDL cholesterol level is attributed to triglyceride enrichment
by cholesterol ester transfer protein and increased hepatic triglyceride lipase activity (Brunzell and Hokanson., 1999). Although HDL particles are produced by the liver, a significant portion of them are formed from remnant particles of TG-rich lipoproteins as they are metabolized. This metabolism is often defective in diabetes, reducing the production of HDL-C from this source, a protein called cholesterol ester transport protein (CETP) transports cholesterol ester away from HDL particles in exchange for TG from VLDL particles. This transport lowers HDL-C in the blood, which also promotes for small, dense LDL particles (Hu and Willett 2002).

The same results (p<0.05) were found between subgroups (Type1 and Type2) diabetic patients they compared to non diabetic subjects. Elevated lipid and lipoprotein level in diabetic patients may be due to insulin resistance because impaired insulin action increase free fatty acid release from intra-abdominal adipose tissue promoting lipoprotein lipase activity results in reduced triglyceride clearance (Ganong, 2003). The same findings were reported in other studies (Jacobs et al., 2005; Bays., 2003; Austin et al., 1996, Imamura et al., 1993; Suryawanshi et al., 2006; Idogun et al., 2007; Albrki et al., 2007). ' (Ceriello and Motz., 2004).

lipid levels effected with glucose levels because carbohydrates and lipid metabolism are interrelated to each other if there is any disorder in carbohydrate metabolism will lead disorder in lipid metabolism so there is high concentration of cholesterol and triglycerides and due to this there is reduction in HDL cholesterol levels because insulin resistance with or without hyperglycemia is associated with qualitative changes in the lipid profile (Lamarche et al., 1998).

Similar findings were obtained by other researchers (Carr et al., 2000; Mathews et al., 1994; Berestein et al., 1993; Bani et al 2008).

4.3.1. Gender and Diabetes Mellitus:

Both male and female diabetic patients were overweight and females had significantly higher BMI than males (p=0.001). But no significant difference (p>0.05) were found between them in levels of GL, TC, TG, LDL-C, HDL-C and VLDL-C.

It might be related to different degrees of insulin resistance between the two sexes or to a direct effect of the hormonal status on one or more enzymes implicated in lipoprotein metabolism (Jenkins et al., 2003).

In addition, many variables may have different effects such as age at onset of disease, duration of diabetes and HbA1c and drug compliance (Gloria-Bothini et al., 2000;
Dietary compositions seem to affect the lipid profile (Yong et al., 1996). Also physical activities, obesity, hypertension, smoking, contraceptive use, environment, occupation and level of education and certain genetic predisposing factors of the population (Webber et al., 1992; Schiekem., 1992; Tenkate et al., 1982; Quivers et al., 1992; Hodge et al., 2007).

Higher levels of fat in the cells prevent the action of insulin, and so produce insulin resistance and type2 DM development. The high prevalence of obesity has largely been attributed to the dietary habits, which include high intake of fatty and sweet foods and dates, lack of physical activity (El-Hazmi and Warsy., 1997).

Same results were reported by other researches (Vinter-Repalust et al., 2007; Gustafsson et al., 2004). (Schwab et al., 2006).

4.3.2. Correlation between Glucose and Lipid Profile:

There was a significant positive linear correlation between elevated blood glucose and total cholesterol, triglycerides, LDL and negative correlation between glucose and HDL -C. This is an important finding which shows that hyperglycemia is closely associated with hypercholesterolemia, hypertriglyceridemia, elevated LDL, and reduced HDL which are all documented as risk factors for CHD.

Therefore diabetic patients with lack of diabetic control (high FBS) have higher lipids, less HDL cholesterol. This also points to the significance of control of blood glucose in diabetic patients.

In addition, correlation studies within the lipid groups also showed interesting results. As cholesterol increased, it was accompanied with increase in triglyceride, LDL and a while HDL decreased. Similar findings with triglyceride levels, which correlated positively with VLDL and LDL, but negatively with HDL. These results stress the need for control of plasma cholesterol and triglyceride levels in order to have lower LDL levels and elevated HDL levels. These latter two parameters (Low LDL and high HDL) are also protective against CHD. This shows that the various lipids and lipoproteins are closely correlated with each other, and control of one influences the others.

This is in agreement with the reports of (El- Hazmy and Warsy 1994 and Hague., 1994). That long-standing hyperglycemia rather than blood glucose level is broadly related to the diabetic complications seen in the diabetics.
The correlation analysis carried out in this study showed that increases in the duration of diabetes, glucose and lipid values were significantly increased. This increase may be due to poor glycemic control and age-related pathology with duration of diabetes are thought to accelerate degenerative changes in a cooperative manner (Kitabchi and Bryer., 1997; Colwell., 1996). This finding was in agreement with (Verma et al., 2006; Khalaf Allah., 2008).

4.4. Healthcare of Diabetic Patients:

Diabetes is a chronic illness that requires continuing medical care and patient self-management education to prevent acute complications and to reduce the risk of long-term complications (Rice and Jack., 2006). The quality of diabetes care was assessed by studying the performance of patients care. The study found 30% of patients were preparatory educated and only 35% of diabetic patients were suffering from hypertension, which is lower than reported by Harris 54% in Mexican-Americans, 66% in Caucasians and 71% in African-Americans (Harris et al., 2001). This low level of hypertension is probably related to the fact that 65% of our patients had no blood pressure check-up. Assessment of renal function was done in 45% of our patients, compared with 84% in Sweden and 71.4% in England.

Diabetic retinopathy is one of the leading causes of vision loss worldwide. About 36% of diabetic patients did not know the ocular effects of diabetes, comparable to 21.5% from Australia (Brechner et al., 1993).

Only 10% of patients were suffering from foot ulcer because the risk of ulcers or amputations is increased in people who have had diabetes > 10 years, with poor glucose control, or have cardiovascular, retinal, or renal complications. Most of patients in this study 41% have diabetes from (1-5) years (A D A., 2005).

Exercise is an important component in the management of diabetes, only 33% of the studied group practice regular exercise. However, this is higher than 31% among African-Americans (Gregg et al., 2001). Although regulation of blood glucose to achieve near normal levels is a primary goal in the management of diabetes, and thus, dietary techniques that limit hyperglycemia following a meal are important in limiting the complications of diabetes (Klein et al., 2004). Only 34% of the patients were checked up by the nutritionist and 60% of them had never had food system.

The study revealed that the patients healthcare and public awareness is very poor and most patients are not controlled and they are unaware of their healthcare. The same
observation was found by NCDs risk factor survey in Khartoum state 2006 (Ministry of Health Khartoum State).

This study was designed to address sexual dysfunction in Sudanese diabetic patients with two tools, first one is filling a questioner and the second is to measure serum testosterone in male diabetics and estrogen in female diabetic patients to correlate their concentration with glucose level and lipid profile compared with their control subjects. But only questioner was done in this study. Sexual dysfunction in diabetic patients is commonly caused by autonomic neuropathy and can affects approximately 75% of men and 35% of women. In this study only 26% of the patients know the effect of diabetes on the sex performance and 82% of diabetic males. Only 4% of the diabetic females observed decrease in sex rate. This may be due to several factors, such as lack of standardized definitions of sexual dysfunction in women, absence of well-validated scales, and societal taboos regarding female sexuality (Rosen and Rosen., 2006; Althof et al., 2005).

Impotence is an impairment or loss of erectile ability sufficient for intercourse with normal libido. Men with diabetes are more than twice as likely to suffer from hypogonadism, also known as low testosterone, compared to other men. The most common sexual difficulties for a woman with diabetes involve problems with arousal, decreased vaginal lubrication during stimulation and anorgasmia. Sexual difficulties may be related to autonomic neuropathy and depression.

This finding was in agreement with result reported by (Al-Gam and El-Tom 2008). They reported impotence in diabetic males was detected in 66 males (66%), among those and erectile dysfunction was found in 52% with severe impotence, in 33% moderated impotence 15% mild impotence. They found factors related to occurrence of impotence such as the duration of disease. Prevalence of diabetic impotence after 10 years since the onset of diagnosis were found to be increased two folds compared to patients less than 10 years and presence of diabetic complications, such as retinopathy while severity related to age and duration of diabetes.
CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

• Serum levels of cholesterol, triglyceride, LDL-cholesterol and very low VLDL-cholesterol elevated in diabetic patient compared to non-diabetic subjects.
• Low level of serum HDL-cholesterol in diabetic patients compared to non-diabetic subjects.
• There is a relation between levels of lipids and duration of diabetes. Inversely correlations were found between triglyceride and HDL-cholesterol may be due to dyslipidemia.
• No gender differences in lipid profile observed in diabetic patients.
• Patients healthcare and public awareness is very low and most patients are not controlled and they are unaware of their condition.
• The majority of diabetic patients are unaware of their healthcare.
• About 82% of males and only 4% females of diabetic patients were feeling decrease in sex rate.
• Relationship between glucose level and sex performance were observed in 72% of male patients and 6% of female patients.

Recommendations:

• Measurement of serum lipid profile should be introduced to the management plan of diabetes.
• More comprehensive studies are need for sex performance.
• Large size of the samples and a long period is needed to study the effect of duration and gender.
• To establish regional and national training courses for diabetic educators and creation of new evidence based management plan for diabetics in Sudan for better healthcare.
• Male diabetic patients should do screening for sex performance in order to manage it.
• Regular test of glycosylated hemoglobin (Hb A1c) for each diabetic patients.


Ministry of Health Khartoum State 2006.


Rosen, L., Rosen, R.C., (2006). Fifty years of FSD research and concepts from Kinsey to the present. In Women’s Sexual Function and Dysfunction: Study,


WHO., (2005).World Health Organization Workshop on Physical Activity and Public Health' that was held in Beijing, People’s Republic of China.


**APPENDIXS**

**Appendix 1: Study Questionnaire of Diabetic Patients**

<table>
<thead>
<tr>
<th>Questionnaire Section 1: General Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ID Number:</strong></td>
</tr>
<tr>
<td><strong>Name:</strong></td>
</tr>
<tr>
<td><strong>Gender:</strong></td>
</tr>
<tr>
<td><strong>Nationality:</strong></td>
</tr>
<tr>
<td><strong>Address:</strong></td>
</tr>
<tr>
<td><strong>Work:</strong></td>
</tr>
<tr>
<td><strong>Level of Education:</strong></td>
</tr>
</tbody>
</table>
  - Are you a smoker? (Yes/No) |
  - If yes, how many cigarettes per day? |
| **Medical History:** | 
  - Do you have a diabetes family history? (Yes/No) |
  - If yes, how many family members? |

<table>
<thead>
<tr>
<th>Questionnaire Section 2: Patient Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date of Admission:</strong></td>
</tr>
<tr>
<td><strong>Decree of Admission:</strong></td>
</tr>
</tbody>
</table>
  - Married/Widowed/Single | 
  | 1- Married/2- Widowed/3- Single/4- Divorced |
| **Number of Children:** | 
  - Natural births | 
  - Induced abortions | 
  - Stillbirths |
| **Current Health Condition:** | 
  - Are you on any medications? (Yes/No) |
  - If yes, what are they? |

<table>
<thead>
<tr>
<th>Questionnaire Section 3: Medical Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Disease:</strong></td>
</tr>
</tbody>
</table>
  - Type I Diabetes Mellitus | 
  | Type II Diabetes Mellitus |
| **Date of Onset:** | |
| **Treatment Method:** | 
  - (A) Insulin (B) Oral Medications (C) Diet Therapy |

**Page 71**
في حالة الانواعين جدد نوع الانواعين

عدد الجرعات: 
الوزن: 
عدد مرات دخول المستشفى: 
هل تتابع/تابعي مع الطبيب بانتظام: 
نعم (فترة المتابعة أسبوعية/شهرية/أخرى)، لا لماذا؟ 
هل عانتي/أعتني من ترقبات نتيجة للسكر؟ لا ( ) 
نعم ( ) منذ متى؟ 

المعنى (فترة المتابعة أسبوع/شهرين/أخرى)

نوع العلاج: أدوية وعقاقير ( ) إزالة العضو ( ) إجراء عملية جراحية ( )

القسم الثالث
الفحصات العملية

ما هي الفحصات العملية التي يتم إجراؤها: 
فحص السكر

عدد مرات الفحص في اليوم: 
زمن الفحص: 
صباح ( ) ظهرا ( ) مساء ( ) عشاء ( )
أخير ( )
نوع الفحص (عمل/جه/فحص السكر) 
فحص البول: 
عدد مرات الفحص: 
نوع الفحص (عمل/جه/فحص السكر)
 Fahs ( ) ظهرا ( ) مساء ( ) عشاء ( )
أخير ( )

فحوصات أخرى

وظائف الكلى: 
وظائف الكبد: 
الكولسترول: 
الدهون الثلاثي: 
إي فحوصات أخرى أجريت لك/لك
القسم الرابع
النظام الغذائي

هل تتابع/تتابع أي نظام غذائي محدد: نعم ( ) لا ( )
بعد فترة من اكتشاف السكري ( ) أخرى/آخر ( )
هل تتبع/تتبع أي نظام غذائي محدد؟ نعم ( ) لا ( )
نوع الغذاء: خضروات ( ) لحم حمراء ( ) بصليات ( ) سلطة خضراء ( )
فواكه ( ) أخر ( )
عدد الوجبات في اليوم: 2 ( ) 3 ( ) 4 ( ) أكثر ( )
آخر/آخر ( )
هل تمارس/تمارسي أي من أنواع الرياضة: نعم ( ) لا ( )
في حالة نعم، حدد نوع الرياضة؟
هل تتم ممارسة الرياضة يومياً نعم ( ) لا ( )
إذا كانت الإجابة بلا كم عدد مرات الممارسة في الأسبوع: مرة واحدة ( ) مرتين ( ) ثلاث مرات ( ) أخر ( )
آخر/آخر/آخر ( )

القسم الخامس
الأسئلة الجنسية

1- هل لديك معلومة عن علاقة مرض السكري بالقدرة الجنسية (الجماع)؟ نعم ( ) لا ( )
في حالة الإجابة بنعم، ما هي المعلومات المتوفرة لديك؟

2- عند الإصابة بالسكري هل تبادر إلى ذهنك أنه يمكن أن تصاب بالقدرة الجنسية؟ نعم ( ) لا ( )
لماذا؟

3- هل يشغل هذا الموضوع حقاً من تفكيرك؟ نعم ( ) لا ( )
لماذا؟

4- هل هناك اختلاف في معدل المعاشيرة الزوجية قبل وبعضاً من المرات؟ نعم ( ) زيادة ( ) نقصان ( )
لا ( )

5- منى لاحظت ذلك؟

6- هل هناك علاقة بين مستوى السكري والقدرة الجنسية؟ نعم ( ) لا ( )

7- هل تتناول/تناول أي من المواد المتشابهة؟ نعم ( ) لا ( )
في حالة نعم ما هي؟ ( ) مقويات ( ) غذاء معين ( ) أخر ( )
آخر/آخر/آخر ( )

8- هل لديك أي من الملاحظات تود إضافتها؟

73
Appendix 2: Study Questionnaire of Non Diabetic Subjects.

Sudan Academy of Sciences (SAS)

Study Questionnaire of non diabetic subject

Serial NO: ....................................................................................................................

Name: ...........................................................................................................................

Sex: ...............................................................................................................................

Age: ..............................................................................................................................

Height: ..........................................................................................................................

Weight: ..........................................................................................................................

Occupation: ..................................................................................................................

Social status: ..............................................................................................................

Residence: ..................................................................................................................

Family History: .........................................................................................................

Any diseases: .............................................................................................................